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# ARMY R&D & A



MAY - JUNE 1998

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## ARMY AFTER NEXT

A VISION FOR THE FUTURE

# FROM THE ARMY ACQUISITION EXECUTIVE

## *Preparing Now For The 21<sup>st</sup> Century*

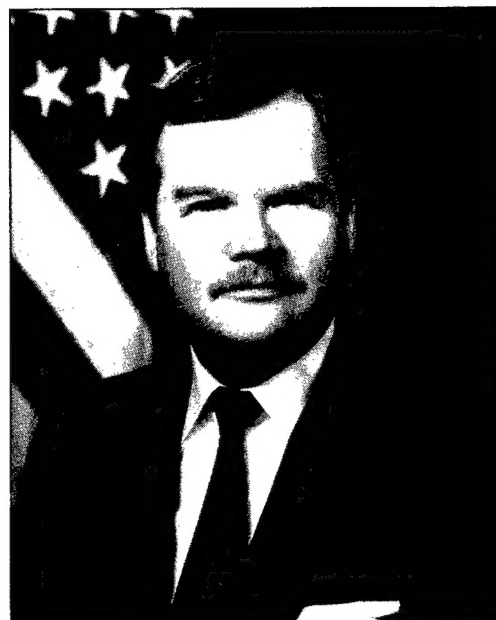
As we stand on the threshold of a new century, the world geopolitical environment suggests that our nation will increasingly call upon America's Army to execute complex, manpower-intensive missions across the full spectrum of military operations. Proliferation of weapons of mass destruction, regional conflicts, transnational threats, and the likely emergence of a major military or regional competitor require a disciplined, focused evolution of our armed forces to meet the challenges of an uncertain future.

By looking beyond the next generation, the Army recognizes that the change necessary to maintain our technological overmatch capability cannot be gained through the traditional Cold War methods. Today, the Army has the unprecedented opportunity to focus on leap-ahead capabilities rather than incremental change. By taking advantage of emerging information technologies, greater efficiencies, new partnerships with industry, and especially the genius and vitality of our soldiers, our Force XXI process will produce a 21st century Army—the Army After Next—capable of securing our nation's future.

The Total Army is going forward together—**one team** of Active, Army National Guard, and U.S. Army Reserve soldiers and civilians—committed to **one fight**—an integrated joint force working in concert to provide for the common defense—and working together for **one future**—a secure America in a safe and prosperous world. To meet these challenges, we must follow six certain principles that guide us today and prepare us for tomorrow.

First, we must always keep our focus on people. Soldiers make the Army work. Soldiers must take care of themselves, take care of their families, and take care of their fellow soldiers. In return, the nation must take care of her soldiers. America's Army will only be as good as its people. Today, America is asking a great deal from the Total Army team. So, Army leaders at all levels must always make decisions with people foremost in mind.

Second, America's Army must always be strategically relevant to the needs of the nation. It must continue to be trained and



ready to fight and win the nation's wars while helping to prevent conflicts, shaping the international environment, promoting our national interests abroad, and influencing democratic values around the globe.

Third, we must modernize the Army now for the 21st century. Warfare in the information age requires new weapons, new doctrine, organization, and training. Our modernization program will focus investments on securing the capabilities needed to transition today's Army into Army XXI and the Army After Next. We are committed to providing the soldier—our most precious resource—with the best chance to prevail quickly and with minimum casualties on the battlefields of today and tomorrow.

Fourth, the Army must always be a disciplined force where men and women from all races, religions, and backgrounds serve together with dignity and respect. We must be an Army of soldiers and civilians who exemplify the values and character of the nation—an Army of citizens who are also soldiers, but first and always Americans.

Fifth, our Army must be a Total Force where each component—Active, Guard, and Reserve—contributes to a seamless team. Our leaders must work together, trust each other, and seek to understand the strengths that each component provides the nation. Together, we must tirelessly work to leverage the capabilities of all the components into one Total Force for America.

Sixth, our Army must be a full partner in the nation's joint military force—a combined team where each Service provides complementary capabilities in support of the National Military Strategy.

Soldiers on the ground are our nation's strongest signal of resolve and the ultimate expression of American will. This has not changed in the 20th century, and it will not change in the 21st century. America's security and its continued role in maintaining world stability cannot be guaranteed without a first-rate, modern Army.

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**ABOUT THE COVER**

The Army After Next Project Office is conducting broad studies to conceptualize the Army's warfighting capabilities out to the year 2025. The vision generated from these studies will be integrated into future combat developments programs.

**DTIC QUALITY INSPECTED**

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# THE ARMY AFTER NEXT

## Intertwining Military Art, Science, And Technology Out To The Year 2025

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By MG Robert H. Scales Jr.  
and Dr. John A. Parmentola

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### Introduction

The Army After Next (AAN) Project Office at Headquarters, U.S. Army Training and Doctrine Command (TRADOC) is conducting broad studies of future warfare for the year 2025 timeframe. The purpose is to isolate the issues vital to the development of the Army. The vision generated from these studies will be integrated into future TRADOC combat developments programs.

Several important dimensions motivate the focus on the 2025 timeframe for AAN. First, given our available lead time and the rapid pace of economic development in a number of evolving countries, it is likely that the United States will encounter a major military competitor or, at the very least, confront significant asymmetric threats in this period.

Second, the year 2025 enables military art and technology experts to divert their thinking from concepts and capabilities associated with the programmed force of Army 2010 to more novel approaches to achieve the AAN vision. It also provides ample lead time to incorporate innovative technologies

and unanticipated revolutionary discoveries into this vision.

Finally, it provides an opportunity to refocus Army basic and applied research on efforts that have significant potential for advancing critical AAN enabling technologies. Thus, TRADOC's AAN efforts will enable the Army to refine its choices as a function of time and optimize its investment decisions to achieve critical AAN warfighter capabilities.

This article describes the assumptions, arguments, and challenges that form the basis for conceptualizing the Army's warfighting capabilities out to the year 2025 and the science and technology support and activities that will enable the Army to eventually realize these capabilities.

### Speed, Knowledge And The Lessons Of History

Cycles of change in warfare are particularly difficult to comprehend and even more difficult to anticipate because, unlike endeavors in finance, medicine, or law, active experience in war is, thankfully, infrequent. Because warfare

is not frequently practiced, soldiers must rely on the laboratory of past experiences to gain vicarious experience in war. To be sure, the frenetic pace of technological change in the modern world has compressed the interval and stretched the amplitude of the cycles of change. Nonetheless, undeniable cycles remain and we should be able to search the recent past to identify new cycles, as illustrated in Figure 1.

With the rise of industrial production and the appearance of precision war-making machinery such as rifled weapons in the mid-19th century, technology began to dominate patterns of change. Such weapons extended the deadly zone, or the distance that soldiers had to cross to engage a defender, from 150 meters in Napoleon's day to 1,000 meters or more by the end of the American Civil War. As the deadly zone increased by nearly a factor of 10, the risks of crossing it were further multiplied by the lethality induced through the precision and volume from the massive proliferation of repeating arms. Thus, technology favored the defender. Images of the terrible slaughter of World War I remain as testimony to the cost in blood exacted by an operational method that relied on a killing effect to achieve decisive results.

The Germans first conceptualized the solution in 1918, and it was deceptively simple: short, highly intense doses of firepower to prepare the assault, small units to exploit the shock effect of firepower to infiltrate and bypass centers of resistance, and operational formations to move through exposed points of weakness and push deep into enemy lines. After the war, the further development of the internal combustion engine provided the means to translate the theory into effective action and restore the dominance of the offensive. Motorized armored vehicles allowed soldiers to cross the deadly zone protected by enormously greater speed while employing blitzkrieg to gain victory. This was achieved through psychological paralysis induced by movement, rather than through butchery induced by massive application of firepower.

After World War II, the challenge was to halt a Soviet-style blitzkrieg across the Northern German Plain. Tactical forces needed defensive killing power to absorb the initial Soviet-armored shock and hold their defensive positions. This led to the defensive forces' return to dominance. The operational problem,

however, was to strike deep offensively to slow the rate of arrival of follow-on armored forces at the front line. The resulting AirLand Battle Doctrine of the 1980s suggested a swing of the pendulum back toward offensive forces. Operation Desert Storm added momentum to the pendulum swing with ground and air forces overwhelming static defenses with unprecedented speed and intensity. Nonetheless, even Desert Storm produced troubling hints that evolving defensive systems threaten to reimpose strategic and operational paralysis. Iraq's SCUD missile attacks on Saudi Arabia and Israel, had they been more accurate or included chemical or biological warheads, might have strengthened Iraq's defense considerably. The proliferation of such systems will substantially raise the stakes of future interventions.

Two key attributes of future U.S. Armed Forces, if harmoniously developed, would firmly re-establish the

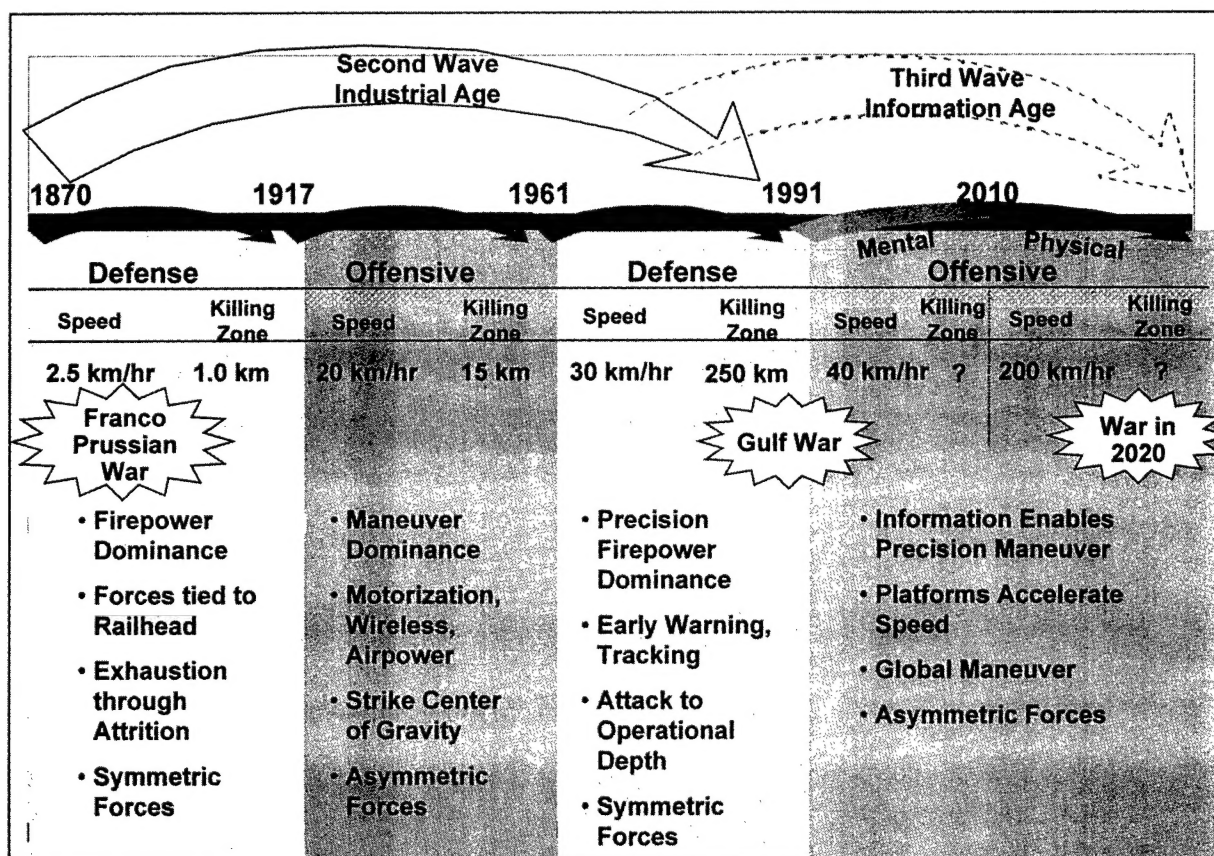
dominance of the offensive forces. The information revolution will likely allow us to define and track the elements of a force with exquisite clarity and detail, but knowledge of the enemy, alone, is not enough. We must possess the means to act on what we know, and action depends on speed. The combination of knowledge and speed of movement will allow a future battle force to anticipate enemy movement and turn costly force-on-force engagements of past wars into surer and less costly engagements by choice.

Much like the evolution of military and private sector capabilities in the 20th century, an important physical parameter influencing the Army After Next is the compression of time. For the Army, this means taking advantage of future advancements in information technologies while concurrently increasing speed or equivalently reducing the time required to strategically deploy, tactically maneuver, traverse the

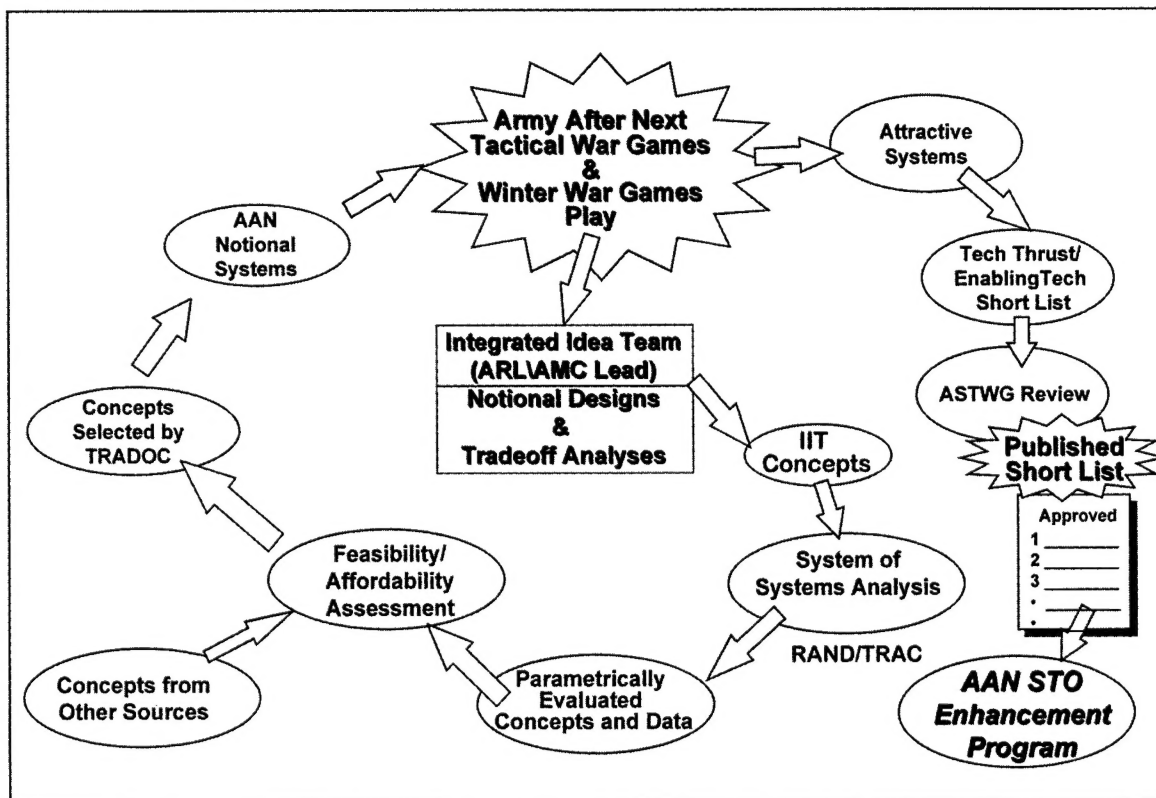
killing zone, deliver metal on target, and provide timely logistic support to the battleforce. To that end, information technologies will allow us to position outside the combat zone all but those forces necessary to move, observe, and kill.

The imperative for speed in this new form of warfare begins at home ports, airfields, and installations. A highly lethal force, shorn of its Cold War impedimenta, will be able to project itself from the homeland or from strategic points overseas in days rather than weeks or months and arrive in the operational theater ready to fight. Strategic speed will allow theater war to take the form of a *coup de main*.

Our goal in applying firepower must be to exploit its substantial paralytic effects to gain advantage. To win quickly and decisively at low cost in the future, we must have the means to conduct the battle quickly and end it cleanly, preferably at the moment when the



**Figure 1.**  
Technology and the cycles of war.



**Figure 2.**  
Science and technology support to the Army After Next development process.

paralytic effect of firepower is greatest. Victory is best guaranteed through maneuver of forces on the ground. Psychological collapse, the breaking of an enemy's will to resist, comes when an opponent is challenged and blocked at all points. A commander with the dual advantage of speed of maneuver and killing power will dominate the battlefield. If these two essential elements of combat power are orchestrated skillfully, an unfettered battle force will be able to strike multiple vital points simultaneously or in a sequence of their choosing. In a very short time, perhaps only hours, such a force would be able to quickly disintegrate an enemy's warfighting structures, producing an unequivocal military decision with minimum cost.

The fourth cycle of war, therefore, should seek to exploit the information age to increase the velocity of maneuver. Speed must be the essential ingredient of a future landpower force. Speed will be achieved by creating a highly mobile force unimpeded by terrain and unburdened by an agility sapping logistical yoke. To achieve the speed of maneuver necessary to wage

21st century knowledge-based warfare will require a new concept of mechanized warfare that will free forces of maneuver inhibiting restrictions. The exploitation of knowledge via increased air and ground mobility will result in unprecedented tactical and operational maneuverability.

Such "air mechanized" battle units would be mechanized combined arms echelons of maneuver capable of air assault to operational depths to attack regimental size units and defend against division sized attacks. These units and the personnel and systems they contain will combine extreme speed with superior knowledge to provide precise maneuverability that takes optimum advantage of deadly accurate firepower. The employment of more maneuverable air mechanized battle forces in advance of potent Army XXI forces would create the capacity for 21st century strategic blitzkrieg. Once again, offensive forces would dominate warfare.

### Intertwining To The Year 2025 And Beyond

The process for intertwining military

art and technology for the AAN is depicted in Figure 2. This process is comprehensive, highly coordinated, and relies on significant levels of cooperation among its participants. It starts with the annual AAN strategic and tactical war games that explore and assess novel concepts of operations and capabilities and then pass through a number of coordinated technology activities and eventually feed back into the AAN war games. This nonlinear process continues until the AAN military art innovations and proposed supporting technologies and systems converge to a feasible, affordable, and militarily significant set of AAN capabilities.

One important output of each yearly cycle of this process is a TRADOC-approved short list of critical AAN enabling technologies that is used to establish new AAN Science and Technology Objectives (STOs) that directly involve private sector participation. This is designed to cultivate a growing private sector involvement in advancing technologies in support of challenging AAN capabilities.

Very early in the AAN study process, the Army recognized that team building

among the military art and technology experts was crucial to the overall success of the AAN effort. This observation led to the concept of Integrated Idea Teams (IITs). The objective of these teams is to assess, from a technological perspective, the concepts, capabilities, and notional systems, including tradeoffs, that support AAN operational characteristics and ideas developed through AAN war games. IITs are managed by the Army Materiel Command (AMC) through the Army Research Laboratory (ARL) and are composed of technical experts from Army laboratories, National Laboratories, the private sector, the Defense Advanced Research Projects Agency (DARPA) and the other Services, and academia, as well as those more involved in the military art side of the AAN.

Once the IIT has developed such concepts, these notional system concept designs are then played in force-on-force/system-of-systems high resolution modeling and simulation exercises conducted in collaboration with Rand Corp., the TRADOC Analysis Center (TRAC), TRADOC, the IIT, and Office of the Assistant Secretary of the Army (Research, Development and Acquisition) (OASARDA). The purpose of this is to assess the military significance of these systems within a larger set of warfighting systems and to determine system performance parameters that make a difference on the battlefield. This effort recognizes that maximizing individual system performance does not necessarily result in a more capable and affordable system.

The final step in this process is to assess the feasibility and affordability of selected concepts through a team of experts from the military laboratories, national laboratories, the private sector, and academia. The objective of this effort is to evaluate the IIT notional system designs, in concert with the above force-on-force results, with respect to feasibility (laws of physics, maturity of concept, and schedule) and affordability (development cost, production cost, operations and support costs, and leveraging with the private sector and the other Services and agencies). This effort also provides positive feedback to the IIT on their notional system concept designs. These assessments are then forwarded to TRADOC for review and assessment and the results are used to decide on the role of these notional system concept designs in the next round of the AAN war games.

An example of an emerging insight from the AAN war gaming that was

fleshed out through the IIT process is the concept of air mechanization, which was mentioned earlier. To achieve the requisite speed and agility, 21st century air mechanization will have to derive from new combinations of air and ground vehicles. A plausible option to provide the tactical and operational maneuverability required for the 21st century is to include an advanced airframe designed to be both a lifting and fighting vehicle. It would be able to lift, conformably, members of a family of light advanced ground vehicles with long-range, lightweight, highly accurate armaments. The advanced airframe would connect quickly to an advanced ground vehicle while its crew remains inside. The advanced airframe would transport the vehicle anywhere on the battlefield out to a combat radius within hours and deploy it combat ready. In addition to lifting advanced ground vehicles, the advanced airframe would lift or employ a variety of other mission modules.

All advanced ground vehicles would rarely be required to face main battle tanks head-on, which makes it possible to limit their weight by reducing the need for heavy armor. They will survive through a combination of speed, agility, active protection, signature management and control, comprehensive situational understanding, terrain masking, deception, and indirect fire. Greater ground speed on and off roads will be possible because of advanced suspension systems, power trains, and engines. Greater fuel economies will result from significant weight reduction and advanced propulsion system designs.

Thus far, the AAN study has focused on the challenging air mechanization concept involving a high-speed tiltrotor and several versions of a lightweight, highly lethal, mobile companion ground craft. This concept addresses the following: the need to overcome the limitations of ground vehicle speed by transporting the ground craft at high speed via the tiltrotor within theater; the need for a lightweight ground craft to limit the size of the tiltrotor; and the need to overcome the possible absence of an airfield in theater through the self-deployment of the tiltrotor and ground craft combination from CONUS. This system approach to the AAN air mechanization concept has not completed its first cycle through the AAN process depicted in Figure 2. However, the results so far are very encouraging. The first complete assessment will occur sometime in the summer of 1998.

In addition to this process, a complementary set of activities involving the Army Science Board (ASB) and the National Research Council's Board on Army Science and Technology (BAST) are currently under way. The ASB is investigating opportunities to advance strategic deployment capabilities out to the year 2025, while the BAST is constructing an investment roadmap for the Army Basic and Applied Research Programs for the development of technologies that will significantly reduce logistics demand. Finally, OASARDA, in partnership with TRADOC, is planning to initiate a series of technology-based war games that will assist in determining the most productive investment options to support AAN capabilities.

## Conclusions

We believe the Army has seized upon a highly compelling vision of its future role in land warfare. It has also carefully thought through a comprehensive process that will determine the key science and technology investments enabling it to achieve this vision. The process the Army has created to navigate into the future is working very well. The future Army and the United States will be the beneficiaries of this cooperative but challenging effort.

*Authors Note: The authors would like to acknowledge the contributions of Dr. Doug Lovelace of the Army War College and Dr. Tom Killion of the Army Research Laboratory in the preparation of this article.*

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# COLLABORATIVE TESTING AND EVALUATION

By MG Roy E. Beauchamp,  
Hans E. Guttwein,  
and David R. Castellano

## Introduction

During the last two decades, the Department of Defense (DOD) acquisition community has endeavored to build and field high-quality Defense systems while struggling with the challenge of keeping costs within reasonable expectations. Faced with the growing complexity and diversity of our tactical, strategic and information-based systems, cost containment during design and development has become increasingly difficult. Recent initiatives in acquisition reform aim at building "affordable" systems, and are driving a reevaluation of the entire development life cycle process. One goal is the elimination of redundant or unnecessary testing and evaluation (T&E). This must be accomplished without compromising our principal responsibility to provide soldiers with technologically superior systems that are both safe and effective.

There are three basic phases of a typical development cycle: definition, engineering, and verification. Project managers (PMs) and development laboratories have sought to maximize the payback for every acquisition dollar spent. Placing more emphasis on defining system requirements upfront reduces design volatility, minimizes rework, and keeps costs down. Certainly by applying better engineering practices, we can expect to improve quality and efficiency. But what about T&E, the mandatory portal for system "buy off" by the customer? What about exit criteria, which must be met to the  $n$ th degree,

imposed by three and sometimes four independent T&E communities? Can we find more cost-effective ways to do T&E while maintaining the high quality of our materiel?

## Defining T&E

T&E is conducted at various stages

*During the last two decades, the Department of Defense acquisition community has endeavored to build and field high-quality Defense systems while struggling with the challenge of keeping costs within reasonable expectations.*

during the acquisition of a Defense system, and can be characterized as one of two basic types: **developmental** and **operational**. Developmental and operational T&E are formally defined in Army Regulation (AR) 73-1 (*Test and Evaluation Policy*, Feb. 25, 1995) as follows:

*Developmental T&E is a generic term encompassing engineering type tests used to verify that design risks are minimized, substantiate achievement of contractor technical performance, and certify readiness for operational testing and evaluation.*

*Operational T&E is a generic term encompassing test and experimentation in realistic operational environments with users who represent those expected to operate and maintain the system when it is fielded or deployed.*

## Developmental T&E

Developmental T&E addresses whether or not the design meets the intended customer requirements and ensures design integrity over a system's specified operational and environmental range. Hardware designed in accordance with proposed production specifications is exercised under strict parametric conditions. It is here that reliability, maintainability, availability, and other parameters are validated with high degrees of confidence. For a major program where the live fire legislation applies, a separate live fire test must be conducted to validate that performance requirements (survivability, vulnerability, and lethality) are indeed achieved against actual threat targets.

## Operational T&E

Operational T&E addresses whether or not the system is suitable for field use. It is conducted under realistic operational conditions on a production representative system to determine its operational effectiveness and suitability for use by typical users in combat or when otherwise deployed. Much of the tactical doctrine is fleshed out during this test to ensure operational suitability.

Traditionally, both developmental and operational T&E were conducted separately, with one having little influence on the other because of their diverse test requirements. For example, developmental T&E may validate reliability and accuracy of rounds fired, while operational T&E may validate rates of fire given a particular target scenario. Naturally, this led to some redundancy in testing since there was no sharing of data. While the elimination of either type of T&E is not practical, combining portions of both shows promise as a way to cut test costs and field systems earlier.

## Continuous Evaluation Initiative

In the mid 1980s, the Army initiated a process called **continuous evaluation** to make maximum use of any and all testing efforts. For about 2 years (1985-87), test facilities were "certified" to provide shareable data. These facilities could be the Army's proving grounds, contractor facilities, or Army operational test facilities. The theory was that test data (or results) would be determined "certifiably good," and be used to support engineering design verification, developmental test assessments, and operational evaluations. **Continuous evaluation** would be applicable from early proof-of-principal tests through production testing.

Although a valiant effort, **continuous evaluation** never achieved its full potential. There was never enough confidence built into the test data to assure future evaluators that the information was valid for their specific needs. Separate and independent developmental and operational testing continued to flourish.

## Streamlining T&E

Acquisition reform does provide a significant opportunity for streamlining

*Recent initiatives  
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aim at building  
"affordable" systems,  
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life cycle process.*

T&E, recognizably so because significant costs are incurred for final prove-out, and it is here that the greatest opportunity for gaining fiscal efficiencies exists.

Let us examine and discuss these fiscal opportunities. Streamlining T&E is not a new initiative. T&E organizations throughout the Services have attempted for years to combine or reduce T&E requirements through a number of methods. For example, modeling and simulation (M&S) has been employed somewhat effectively in reducing the scope of both developmental and operational T&E. In an interview in the May-June 1996 issue of *Program Manager*, Philip E. Coyle III, Director of Operational Test and Evaluation (DOT&E), stated his office views M&S as an effective tool for assessing areas that are "... straightforward and tractable ..." but it would not be a substitute for real tests. The premise is that models can be used to eliminate certain tests, thereby refocusing limited test resources on the areas that are less understood.

If one compares the objectives of developmental and operational T&E, they are essentially the same. Both are meant to validate item performance against a set of established requirements. The difference between the two has to do with the conduct of each test, not their respective test objectives. Performance objectives for developmental T&E deal with predetermined thresholds of various requirements, such as accuracy and precision for a weapon system under high and low temperatures, sustainment of opera-

tional capability under an extreme limit vibration schedule, and the reliability and durability of the item under those conditions. Of course, all of these performance parameters are of interest to the operational evaluator, but operationally speaking, it is the warfighter who employs the equipment in the field under dynamic conditions. He or she is not so much interested in measuring the miss distance or aiming error as in hitting a threat target under battlefield conditions. In both cases, hitting a target is the requirement; however, the parameters being measured are different. But does this mean that combining tests is not possible? Let's explore that question.

## Combining Testing

The very natures of pre-production qualification testing and initial operational testing (IOT), coupled with their unique goals, mean that their developmental and operational T&E aspects cannot always be readily combined. However, there are ways to combine portions of each through the sharing of tests and/or test data. The concept is simple: execute one test but collect enough data to satisfy both developmental and operational objectives, or execute individual tests but share the test results. How test results can be shared is best exemplified in the following examples:

- In a controlled environment, conduct live fire testing of a weapon system to collect sufficient parametric data to establish fire control ballistic accuracy and reliability (developmental T&E requirement).

- In a mission scenario, conduct live fire testing of a weapon system to prove out sustained rates of fire (operational T&E requirement).

Data from the mission scenario, if properly instrumented, could be used to reduce the number of rounds required to establish statistically sound accuracy/reliability figures. Likewise, live fire ballistic accuracy/reliability testing could be conducted in a mission scenario to validate rates of fire. In either case, test resources are optimized by collecting data that are usable by both the developmental and operational T&E communities. Both parties, however, must compromise to some degree when using the data for their evaluations. Developmental testers



must accept the integrity of data collected under non-pristine conditions, where variables are allowed to change within reasonable tolerances. Likewise, operational testers must accept test data collected under constrained conditions that attempt to mimic, within reason, a mission scenario. Only after each party takes this major step can the efficiencies become reality.

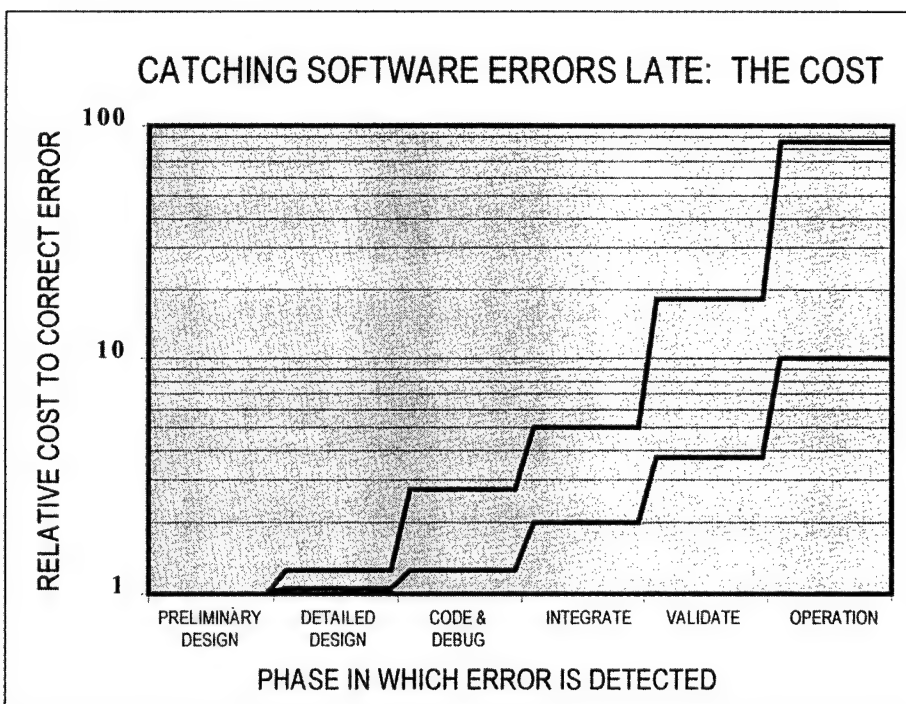
So what is the driving force behind the compromise? It must be a melding of the perspectives among the integrated product team members, who can outline the strategies and derive the cost benefits. The Test Integration Working Group (TIWG) is the vehicle to achieve agreement and coordination. Although developers and evaluators can agree in principle to optimize combined tests, the "devil is really in the details." The process of combining tests to support operational as well as developmental T&E goals will be unique to each program. It will take a TIWG with knowledgeable representatives who have both the authority to make decisions and the will to compromise for this process to be successful.

### Examining Cooperative T&E

Let us take a closer look at the combined developmental and operational T&E approach, as described above. With a little extra effort, it is clear to see that issues such as safety, reliability, and performance can be "assessed" in such a manner that operational T&E mission scenarios and user acceptance can also be "evaluated." There are numerous cases where attempts have been made to "share the data." In fact, Coyle stated that approximately two-thirds of the programs under DOT&E oversight involve a period of combined developmental and operational T&E. As resources continue to diminish, the acquisition community must continue to come to grips with this situation in the true spirit of integrated teaming. Maintain the independence mandated by law and good practice, but also work together to gain efficiencies in T&E that may translate into significant cost reductions.

### Cooperative T&E Of Software-Based Systems

Immature software continues to be the number one cause of operational T&E failure. This is a staggering statement when one considers the dramatic impact on cost and schedule resulting from scrap, rework, and IOT restarts



and reruns. Implications for costs continue to be significant. As shown in the accompanying illustration, the relative cost to fix an error grows logarithmically as a function of when the error is discovered. For example, a software error found late in the development phase of the life cycle can cost as much as 5 to 20 times more to fix than if it were discovered during the design phase. Furthermore, the cost to fix a software error found during fielded operation can range from 10 to 85 times what it would have cost to fix it during the design phase. It is ironic that Dr. Jacques S. Gansler, Under Secretary of Defense for Acquisition and Technology, presented this chart over 20 years ago, and the trends still hold true today!

So the emphasis is clearly on early participation by the independent agents, particularly the PM's or the developer's own independent verification and validation (IV&V) agent. We have found that upfront involvement and **continuous evaluation** tend to work well with software-based systems, yielding software products that are highly mature and robust. We have also found it easier to combine developmental and operational T&E because of greater overlaps in scope and purpose. This is achieved through extensive engineering validation testing, ranging from bench-level to onboard system prove-out, coupled with cooperative efforts

contributed by the developmental assessment, operational evaluation, and user communities.

### Cooperative T&E Case Studies

Two cases described below demonstrate return on investment, not only from actual T&E cost reductions, but also from cost avoidance by finding software errors early during each system's development life cycle.

*M109A6 Self-Propelled Howitzer (Paladin).* The Paladin system, a legacy field artillery centerpiece, recently underwent major modernization, boasting a semi-autonomous fire control system with the sophistication of mid-1990s computer electronics. Paladin was originally "Materiel Released" in 1992 with nearly 200,000 lines of Ada code. It performed flawlessly during developmental and operational T&E, and is by our estimates the first Army software-based system to be fielded without software errors. Operational T&E costs alone were about \$7 million.

In 1993, Paladin underwent a major software upgrade to maintain compliance with changes to command, control and communication protocols. It was during this upgrade effort that significant cost reductions were achieved. Developmental T&E was eliminated by combining T&E requirements, sharing data from engineering validation tests,

and from previously successful coordination efforts and cooperation extended by the IV&V agent. Operational T&E was minimized to consist of a command, control and communications interoperability test to validate compliance. The net cost avoidance was in the millions of dollars, and Paladin was again fielded with no known software errors.

In 1996, Paladin underwent further extensive software upgrades, when onboard computers were converted from 16-bit to 32-bit architectures, and in late 1997, when the custom onboard computers were replaced with a commercial off-the-shelf Pentium computer with the Windows NT operating system. Again, no developmental or operational T&E was required as a result of extensive cooperation and sharing data from the engineering validation tests. In both instances, millions of dollars in testing costs were avoided, and Paladin was fielded with no known software errors.

Further Paladin software upgrades are planned and anticipated as additional field requirements are mandated. By continuing the strategies of test consolidation, vigorous coordination, and extensive cooperation, additional financial and functional successes are expected.

**M30 Improved Mortar Ballistic Computer (IMBC).** The M30 IMBC system is a hand-held, militarized laptop running fire control software for 81 mm and 120 mm mortar systems. It boasts a wide range of tactical mission scenarios, mortar ammunition, and mortar system configurations. The IMBC has nearly 130,000 lines of Ada code, and is scheduled for initial release in 1998.

As a new software-intensive system, PM-Mortars (the developer) and the U.S. Army Tank-automotive and Armaments Command's (TACOM's) Armament Research, Development and Engineering Center (its IV&V agent) took great measures from the beginning to ensure full and complete integration of the developmental assessor and operational evaluator. As a result, the developmental T&E has been eliminated in lieu of extensive engineering validation tests conducted during IV&V. In addition, the operational T&E has been greatly minimized, consisting of user training and minor tactical validation. The net cost avoidance is estimated to be \$1 million to \$2 million. Also, an additional cost avoidance of \$200,000 was achieved by further refin-

ing the process of sharing performance and reliability test data.

The examples cited are only two of the many examples of significant cost avoidance attributable to collaborative T&E. As DOD moves forward and institutionalizes collaborative T&E, even more efficiencies will be realized. Empowering the TIWG with both the responsibility and authority to find the best way to test and evaluate a program can achieve startling results.

## Conclusion

Testing and evaluation of systems, subsystems and components is a critical dimension of the systems development business. This process is critical because of the extreme conditions under which equipment is used. If equipment does not perform, soldiers die. That is a powerful and compelling reason to require rigorous and demanding T&E.

However, there are other realities that require consideration. For example, we have technology that can assist in the conduct of T&E in ways that were not possible a few years ago. We have modeling and simulation capabilities with the attendant information processing and computer capabilities to enable us to replicate dynamic operating environments that were hardly imaginable a few years ago. Perhaps equally important is the widely understood necessity to reduce the costs and cycle times of weapons systems development while maintaining our qualitative edge that is the keystone of our warfighting capability. We simply cannot afford unnecessary processes. This does not mean that we will not do operational and/or developmental T&E. It may mean we will do fewer tests, fire fewer rounds, or drive fewer miles.

The concept of collaborative T&E, sharing tests and data, is one way to help achieve these efficiencies. No one is suggesting a relaxation of the standards or a compromise of the quality of materiel put in the hands of soldiers. It means finding better and more cost-effective ways of doing business. It means developing meaningful partnerships with contractors and systems developers and fully involving the T&E community at the beginning. Collaborative T&E can help us do all of this if we are willing, courageous, and creative enough to "check our baggage" at the door when we begin the development. This is what acquisition

reform is all about.

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# LIFE CYCLE COST DRIVERS FROM THE PROGRAM MANAGER'S PERSPECTIVE

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By BG Joseph L. Yakovac  
and Wesley L. Glasgow

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## Introduction

The Program Manager (PM) in today's environment of constrained resources faces many challenges in managing military developmental systems. While the challenges and obstacles are daunting, some can be opportunities if viewed as such and managed accordingly. Making the PM a major participant in managing the total Life Cycle Cost (LCC) for Acquisition Category (ACAT) systems is one such challenge. Even though this seemingly new approach to systems management is formalized, the question is whether this really is a new challenge and, if so, what new opportunities can the PM seize to make his or her system better and more cost efficient?

The purpose of this article is to put the issue of LCC management into perspective—the PM's perspective—and to offer a view on potential opportunities afforded by the new formalized approach to LCC management. The recent emphasis stems from the impression that the PM tends to lose focus on LCCs once the system enters production. This impression is debatable to some PMs who believe they have always performed this responsibility. Regardless of where LCC accountability resided in the past, there's opportunity now for the PM to

marshal forces toward controlling Operations and Support (O&S) costs (a major component of LCC) that systems accrue after fielding.

While continuing to recognize that LCCs must be controlled and reduced, the PM now has the mandate to implement a systematic program consisting of a mix of planned system upgrades and retrofits, Modernization Through Spares (MTS) strategies, and other investment means. This will ensure that systems remain safe and usable for the soldier, yet achieve a continuous balance between capability requirements and LCCs.

## The PM As Life Cycle Manager

Most PMs consider themselves to be part of the life cycle system management team. However, the PM's vision extends principally to major system upgrades through the production run years and ends with transition of the program to Level II or Level III management. During direct management of the system, the PM has always strived to provide best value and procure the best system given the available resources. But the scope of his or her purview necessarily encompassed the areas it was possible to control with the means at hand.

For example, in the Bradley Fighting Vehicle System (BFVS), two major significant capability improvements—the A1 and A2 modifications—were “cut” into the production run and now the third formal modification—the A3—is in development. Each modification added significant capabilities to the basic “A0” model, however, because added capability was the priority, the LCC was also affected.

The specified Mean Mile Between Failure (MMBF) requirement for the BFVS (A0) was 240 miles, but as a result of continuous team effort, the MMBF steadily improved to where the A2 achieved a standard of 720 MMBF—a three-fold increase. Such statistics translate into improved operational readiness, reduced need for maintenance, and greater efficiency in using consumable expenditures, each contributing to reduced total LCC. This achievement was largely possible due to the lengthy production run for the Bradley system, where typically 10 percent of budgeted production dollars were put toward system improvements.

In addition, the BFVS A3 upgrade eliminated a capability as a direct result of the real impacts of LCC. The original Bradley had the requirement to swim, if necessary, across tactical water obstacles to maintain surprise and momentum in the attack. The downside of this requirement was the significant cost of the technical features necessary to make every vehicle in the fleet have this capability. It simply became too cost prohibitive to retain this requirement in view of actual tactical experience that seldom required this capability and the fact that other changes required corresponding changes to the swim features. LCC became the final argument that caused a reduction in the requirement.

## System Technical Support

The major tool that made the BFVS reliability and capability gains possible was the robust System Technical Support (STS) effort built into the assorted contracts. The STS effort allowed considerable supplementary test and evaluation of subsystems and components and provided hard analysis to assist modification decisionmaking. This, however, was somewhat of a luxury based upon the long and stable production run that the Bradley system experienced. A steady and long production run probably can no longer be counted on for extensive product improvement planning.

This article does not address the equipment modification and STS tools in detail because they are familiar processes in the PM repertoire. The point is that all PMs must continuously attempt to incorporate aspects of technical insertion and reduce LCC. This can be accomplished by PMs:

- Having their user buy into life cycle management (LCM);
- Learning to analyze all of the data available on system cost drivers;
- Leveraging resources normally not pursued by PMs; and

- The Army making a commitment to life cycle investment.

## What's On The Horizon

Despite best efforts of the PM to control LCCs, the reality is that the operational requirements of the system sometime mitigate against fully controlling costs, especially when dealing with advanced and unproven technology. The Operational Requirements Document (ORD) formulates the basic requirements for the system, but currently there are few "filters" for cost control in the ORD language. Instead, it constantly devolves to the materiel developer/combat developer "team" to trade off requirements against what is achievable and what is affordable.

The give and take between the materiel and combat developer roles is nothing new, but perhaps it's time to establish a slightly different priority paradigm in view of the emerging presence of LCC management. Figure 1 depicts such an approach where a small change in priority might cast a different aspect on the success of the PM in managing LCCs.

As shown in the figure, safety always takes precedence in the consideration of materiel changes, but now is the time to supplant operational capability increases with LCC considerations in second place.

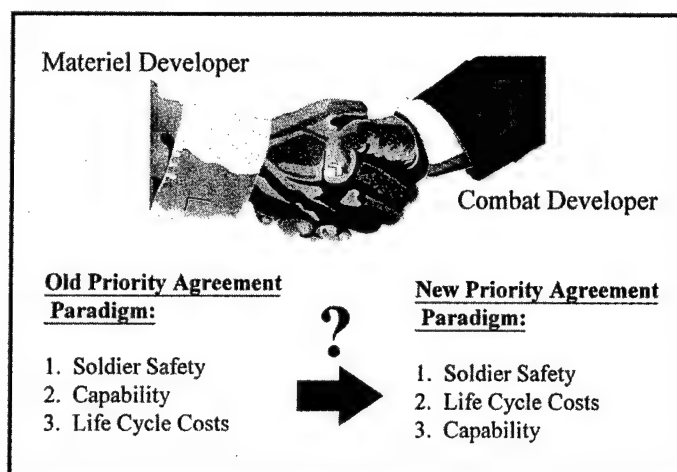
When given the luxury of lengthy production runs, the opportunity for materiel changes applied to the production stream is a normal strategy, but there is a downside. The system tends to stretch its capability envelope over time, and funding and emphasis on capability increases tend to dwindle, save those for safety problems, after the system is fielded. Further, increased resources are required to support fielded systems as their technology becomes dated and spares become less available at reasonable cost.

The burden of supporting technologically obsolescent systems was an acceptable drawback when a replacement system existed on the developmental horizon. New developmental programs today, however, tend to be the exception rather than the rule. The situation now presents challenge or opportunity since the PM is firmly ensconced with the task of controlling the total LCC for the system.

## Modernization Through Spares

The answer is a more deliberate effort to invest in product improvement not only of the system but the subsystems (repairables) and spares (consumables) that will support the system as long as it's fielded. The MTS Program is the principal means to upgrade subsystems and spares to incorporate more recent and less costly technologies in an efficient manner.

The thought process for taking advantage of MTS involves several angles. Early planning is key. To prepare for MTS, the system has to incorporate certain facilities from the



**Figure 1.**  
The PM/user prioritized view of requirements.

beginning. These preparations, called "designing for modernization," entail measures such as "open" system architecture, modular replacement and software partitioning to simplify the use of "pull-out/plugin" modules. The use of performance specifications is also key to hopes of using more flexible commercial standards and specifications.

These features have always been in the PM's tool bag and were seldom overlooked in the development of a program acquisition strategy. The problem for most programs was, and continues to be, resourcing. Strategies effective in the days when a long production run and strong resources were available are more problematic today. In today's environment, a conscious effort must be applied throughout the Army to fund MTS programs to address the real cost drivers that drive up the total LCC. Such a program can be implemented in many ways, but all responsible leaders must realize that to make a product, any product, better requires a level of investment.

## Legacy Systems

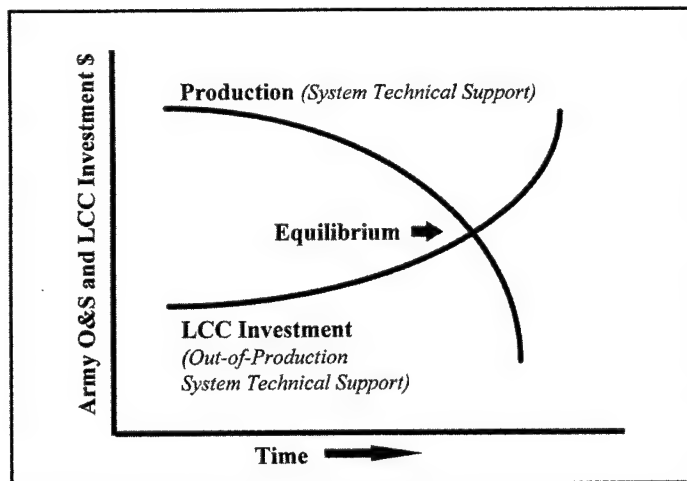
To address the whole range of LCC, legacy systems must also be considered. A tendency exists to make investments in a few major systems that represent the Army's pacing combat systems. Table 1 shows how a handful of systems account for over two thirds of the Tank-automotive and Armaments Command's (TACOM's) total purchases. But one must remember that the effectiveness of many of these systems, in a tactical sense, is affected by lesser known systems that represent significant continuing O&S cost drivers.

An example is the Armored Vehicle Launch Bridge (AVLB) system mounted on the venerable M60 tank chassis. This system, representing a critical irreplaceable combat function, is scheduled to be upgraded with the Wolverine Heavy Assault Bridge system. The problem is that we will never buy enough Wolverines to replace all the AVLBs. Therefore, we will have many AVLBs in the inventory for years to come. The manager of the AVLB must have access to resources to

System	Total Purchases (\$M, FY97)	% of Total	10% Reinvest (\$M)
Abrams	\$ 383.9	44.4	\$ 38.4
Bradley	83.6	9.7	8.4
M88 Rec Veh	72.7	8.4	7.3
HMMWV	50.3	5.8	5.0
All Others	273.3	31.6	27.3
TOTALS	\$ 863.8	100.0	\$ 86.4

**Table 1.**  
TACOM total spares and repairable purchases by military system.





**Figure 2.**  
Life Cycle Cost  
investment  
curves.

address his or her cost drivers.

In short, an investment curve in funding for O&S cost reduction needs to rise to correspond to decreases in production investment funding to keep equipment readiness in equilibrium and LCC down. A spending approach to provide for real O&S cost reduction might appear such as that shown in Figure 2. Investment must include not only the advanced digital equipment but important legacy systems like the AVLB as well. Some of the investment must be expended to improve data collection to identify the most significant system cost drivers.

Several powerful tools exist to assist in identifying the real cost drivers. The Operating and Support Management Information System (OSMIS), Fielded Vehicle Performance Data System, and others are useful tools; however, the PMs must understand the limitations of the data provided by each of these tools and how to use them. The PM team must range further afield to incorporate representatives from the Integrated Materiel Management Center, the Defense Logistics Agency (DLA), contrac-

tors and others with specialized knowledge in this area to help lay out LCC strategy and budget goals and objectives.

### Tasks

The primary tasks for the PM in this environment are to be as knowledgeable as possible of his or her system cost drivers down to the third and fourth tier of the Work Breakdown Structure, and know how to obtain funding for LCC improvements. He or she can partially accomplish tasks by maximizing the use of LCM Integrated Process Teams, which consist of the logistics experts within his/her supporting commands.

The second task is the harder task for the Army and that is to marshal a set of resources the PM can routinely tap into for good LCC ideas. The funds must be economically dispersed so all systems can gain support for their valid cost drivers. The Army must recognize the need to invest especially more heavily in legacy systems where cost drivers will increasingly pinch in the years ahead. Money is beginning to be provided from venues such as O&S cost reduction (OSCR) accounts and DLA's Savings Through Value Enhancement (\$AVE) Program, but better methods need to be developed to capture savings and plow investment funds back into programs in a timely fashion. For example, from Table 1, if only a 10 percent savings was achieved in LCC in each of the programs listed, that would yield more than \$59 million as potential investment resourcing for programs to achieve further efficiencies.

Ultimately, the efforts of the PM to reduce O&S costs must be rewarded with additional resourcing. This is difficult if the Training Resource Model (TRM) used to resource field units lags the introduction of the PM's efforts in LCC savings. To fully benefit efforts in OSCR, some proportion of resources realized through upgrading systems or parts savings at the unit level should rebound to the PM for further investment. At the unit level, there are always unfunded requirements that will consume any savings from PM investment efforts.

Rather than units consuming all LCC savings on their requirements, it may be time to

explore means for the materiel developer, the combat developer, OSMIS and TRM managers, and others involved to devise an equitable formula for savings distribution upfront as a new, more reliable system is fielded or a significant cost driver is redressed. The resultant funding can affect further force modernization improvements and/or OSCR for legacy systems as well as systems in production. The downside, of course, is that units already strapped for resources will be directly effected with the reduced funding level available, but this is balanced somewhat by the continually improving reliability and the overall reduced costs of the equipment the soldier uses to conduct the mission.

### Conclusion

In conclusion, PMs have never been out of the loop in the management of LCCs. They budget to reduce them and employ their entire teams in designing a system that attempts to minimize the cost of ownership in every subsystem. Responsibility for product improvement is constantly emphasized in PM system acquisition strategies. The success of our PM efforts is evident in the proven success of currently fielded systems. We need to build on this success, continue to refine the legacy systems, and enable the PM to be a partner in the Operations and Maintenance Army world expanding his or her efforts at reducing O&S costs.

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**Responsibility  
for  
product  
improvement  
is constantly  
emphasized  
in PM  
system  
acquisition  
strategies.**

# A NEW APPROACH TO THE ARMY MANUFACTURING TECHNOLOGY PROGRAM

## Introduction

A robust, well-focused science and technology (S&T) program is essential for the Army to achieve its goal of providing the warfighter with the most capable, advanced weapon systems. However, even the most promising systems conceived and developed as a result of the Army's S&T Program will never reach the field if they are too expensive to produce, particularly in the current budget-constrained environment.

Because of the increased focus on affordability, the Army's Manufacturing Technology (MANTECH) Program has become an essential element of the S&T Program. The primary goal of the Army MANTECH Program is to provide essential manufacturing technologies that will enable affordable production and sustainment of future weapon systems. Managed by the Army Materiel Command (AMC), the MANTECH Program offers an opportunity to address affordability as early in the life cycle as possible. Because it focuses on maturing and validating emerging manufacturing technologies that result in reduced costs, improved quality, and reduced cycle time, the Army MANTECH Program also can reduce program risk.

In previous years, the MANTECH Program addressed many important manufacturing issues, spreading available funding among various AMC commodity areas to solve problems in a broad range of technical areas. Initially, these efforts were quite successful. In recent years, however, the program has suffered severe funding decrements as well as significant funding instabilities created by multiple and substantial 1-year Congressional requests for special interest projects. In FY97, MANTECH discretionary funding levels reached an all-time low, making it imperative for the Army to rethink its MANTECH strategy.

## New MANTECH Initiative

In FY98, the Army implemented a new initiative to refocus and enhance the MANTECH Program using the Army Science and Technology Objectives

By Dr. Marilyn M. Freeman,  
Carol Gardinier, and  
Dr. Robert S. Rohde

(STOs) as a model and the Army Science and Technology Working Group (ASTWG) as a vehicle for moving the MANTECH Program into the Army S&T mainstream. The Army devised a strategy in which funds of multiple PMs and industry will supplement MANTECH funds to address selected cross-cutting manufacturing issues that promise maximum return on investment.

At the heart of the new MANTECH strategy is the creation of a small number of manufacturing technology objectives (MTOs) that will be analogous to STOs, comprising general and specific manufacturing objectives. MTO managers will be designated with each having specific PM

customers. Each MTO will be completed in 3 to 5 years and funded at \$1 million to \$3 million per year. A goal is to have MTOs consume approximately 50 percent of the total MANTECH funding. In addition, there will be a number of manufacturing demonstrations (MDs), each spanning 1 to 3 years in length and funded at \$300,000 to \$1 million per year.

Figure 1 shows the path through which STOs are proposed and recommended to the ASTWG for final approval. Just as the U.S. Army Training and Doctrine Command is the customer for STOs and Advanced Technology Demonstrations, program executive officers (PEOs) and PMs are the customers for MANTECH efforts. Therefore, MTOs will be processed through a parallel path in which the PEO/PM community has significant input to the ASTWG.

## MANTECH Technical Council

Another key player in this process is the MANTECH Technical Council (MTTC), which has been established to review the MANTECH Program annually and approve

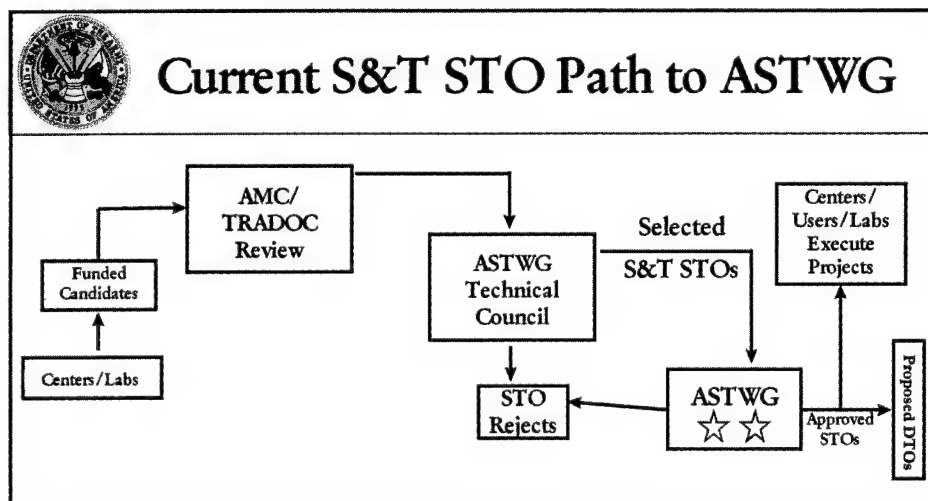


Figure 1.





# MTO Approval Process

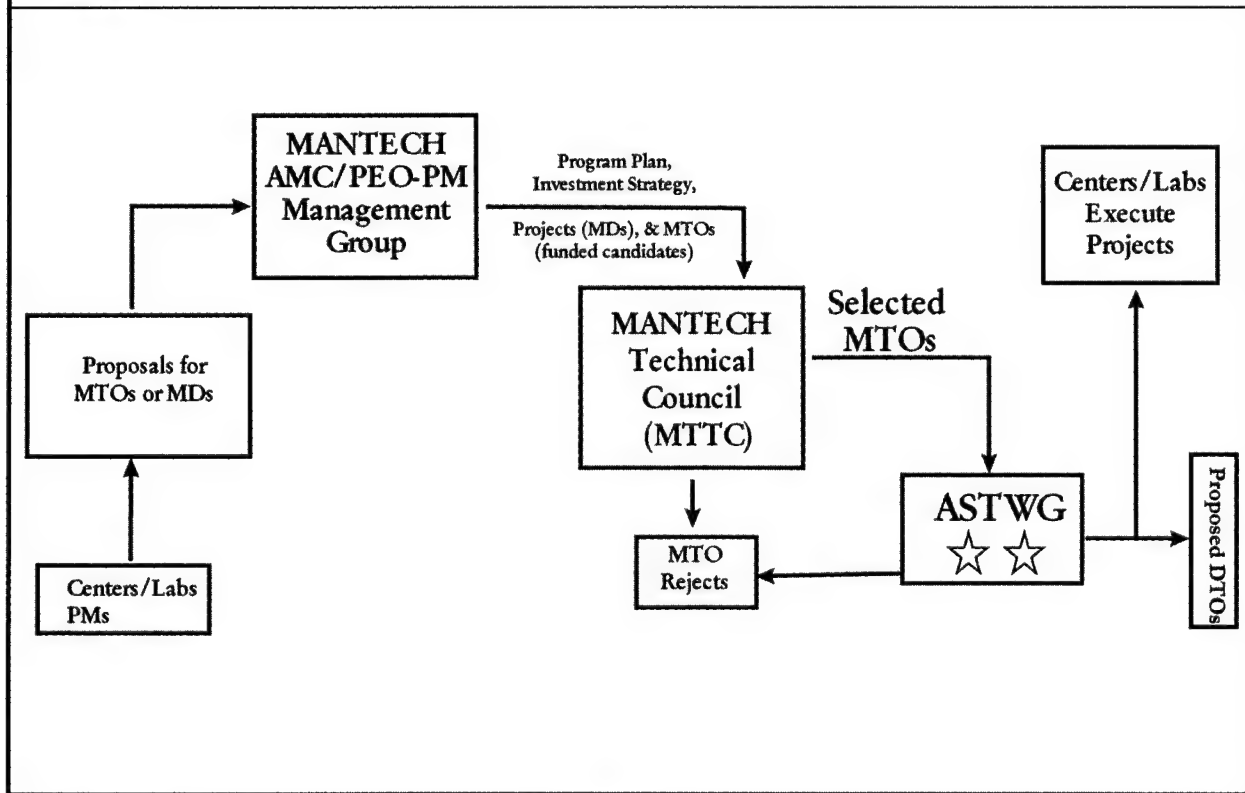


Figure 2.

the MTOs (Figure 2). Members of the MTTC include representatives from the Office of the Deputy Assistant Secretary of the Army for Research and Technology (SARD-TR and SARD-ZS), the Office of the Army Deputy Chief of Staff for Operations and Plans (DAMO-FD), and HQ AMC (AMCRDA-T). Figure 3 shows the MTTC responsibilities. The MTTC will scrutinize each MTO proposal and prioritize the candidates to ensure that those that go forward have the broadest Army/customer

proponency, have sufficient discretionary funding to ensure success, maximize leveraging opportunities, and offer the greatest "bang for the buck." Only the top-rated MTOs approved by the MTTC will be forwarded to the ASTWG for final approval.

The first MTTC meeting was held in November 1997, and one MTO was approved for initiation in FY98. That MTO addresses manufacturing issues associated with reducing the costs of pro-

ducing infrared cooled and uncooled staring arrays. Because focal plane arrays are essential elements in a significant number of Army systems, it is expected that there will be significant cost savings achieved through this effort. During FY98, new MTO and/or MD candidate projects may be submitted to the AMC representative for consideration at the next MTTC meeting. Two other MTOs were approved for FY99 starts. One will address development of plastic

*Managed by the Army Materiel Command,  
the MANTECH Program  
offers an opportunity  
to address affordability  
as early in the life cycle  
as possible.*



# MANTECH Management Oversight

## MTTC Responsibilities

OASA(RDA)  
(SARD-TR)

ODCSOPS  
(DAMO-FD)

OAMCRDA  
(AMCRDA-T)

- Establish Army MANTECH program objectives
- Review the Army MANTECH (MT) investment strategy and program
- Review, revise and forward MTOs to the ASTWG for approval
- Provide broad guidance and programmatic input to the AMC/PEO-PM Review Panel

OASA(RDA)  
(SARD-ZS)

## MT AMC/PEO Management Group Responsibilities

AMC  
PEO-PM  
Reps

- Issue annual call for projects to field & canvas PEOs/PMs to identify most critical manufacturing issues
- Formulate, coordinate and integrate MT projects
- Review, assess, evaluate, revise and prioritize MT projects within guidelines from MTTC
- Submit an MT Program Plan to the MTTC annually

OASA(RDA)  
(SARD-ZS)  
PEO-PM Reps

OAMCRDA  
(AMCRDA-T)

OASA(RDA)  
(SARD-TR)

ODCSOPS  
(DAMO-FD)

Figure 3.

encapsulated microcircuits, and the other will address affordable manufacture of composite structures.

### Conclusion

As the new MANTECH strategy demonstrates that significant cost savings can be achieved with relatively small investments in manufacturing technology early in materiel development, the Army leadership believes the downward funding trend associated with MANTECH will be reversed. In the future, MTOs, in addition to the 200 Army STOs, will comprise the centerpiece of the Army S&T Program.

During FY98, steps will be taken, using the same process and the MTTC, to manage two related cost savings programs: the Reliability, Maintainability and Sustainability (RM&S) Program for Operation and Sustainment Cost Reduction; and the Commercial Operation and

Sustainment Savings Initiative (COSSI) Program.

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## R&D Achievement Awards . . .

# ARMY RECOGNIZES 53 ENGINEERS AND SCIENTISTS

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By Daniel C. Oimoen

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One of the highest honors the Assistant Secretary of the Army for Research, Development and Acquisition can bestow on members of the engineering and scientific community is the Department of the Army Research and Development (R&D) Achievement Award. This prestigious award recognizes outstanding Army engineering and science achievements that have resulted in improved U.S. Army capabilities and contributed to the nation's welfare.

Each year, every major Army command nominates personnel (individuals or small teams) for the award based on their achievements in conducting or leading outstanding R&D efforts during the previous year. Nominations are reviewed by an Evaluation Committee of highly qualified members of the Army science and technology community headed by the Director for Research and Laboratory Management. Achievements are evaluated on the basis of their overall quality, technical merit, importance to the Army, and contribution to the national interest. Nominations that represent truly outstanding achievements are selected to receive the award.

The 1997 Evaluation Committee selected 53 Army engineers and scientists to receive awards for work conducted in 1996. Below is a list of the award winners and their achievements, grouped by com-

mand and organization. Each individual will receive an official letter of commendation and an award plaque, to be presented at the 1998 Army Science Conference in June.

### U.S. ARMY CORPS OF ENGINEERS

#### *U.S. Army Waterways Experiment Station*

*Roy E. Leach* will receive an award for development of a new method of cleaning relief wells and drains. These wells and drains assist in controlling seepage at water-regulating structures. Leach developed the "Blended Chemical Heat Treatment Method" while researching the problem of bacterial clogging in relief wells and drains. This method, which has now been adapted for industrial use, increases effectiveness and can cut lifetime costs up to 50 percent.

*Dr. James T. Baylot, Tommy L. Bevins, and Dr. Raju R. Namburu* will be recognized for their achievement in successfully developing high-performance scientific computing tools to analyze water-tamped, near-surface, cylindrical explosion phenomena and damage of multistory concrete buildings to protect overseas U.S. forces from terrorist attacks. This technology provides a significant new modeling

and simulation capability (using the most advanced high-performance computing assets in DOD) to the Army and DOD to develop a technology base for designing and/or retrofitting military facilities to ensure their security and survivability against terrorist attacks.

*Alejandro R. Carrillo, Charles S. Jones, and John E. West* will be cited for developing a real-time simulation system that allows interactive visualization and steering of numerical computations. This capability integrates distributed, heterogeneous high performance computational resources with high-speed networks and graphics workstations to allow engineers and scientists to interactively investigate the behavior of scientific processes being modeled via a computational simulation. This is a fundamental technology critical to the development of a next generation numerical simulator.

*Robert A. Davidson, John F. George, and Dr. John M. Nestler* were selected for the award for their efforts in improving the passage, health, and protection of salmon in the Pacific Northwest. They improved knowledge of how hydraulics and hydraulic structures affect salmon, and identified new technology that led to development and installation of a prototype underwater, high-frequency sound fish protection system. Ultimately, this technology will be used to protect other

ecologically important fish.

*John F. George, Dr. John E. Hite Jr., and Charles H. Tate Jr.* will be recognized for their achievement in assisting in the development of the Los Angeles County Drainage Area Project. Their contributions resulted in significantly reducing the construction time and total project cost while increasing the level of flood protection for this area. Densely populated, this area is nationally important due to the volume of international commerce that passes through it. This project is still being modified at the request of local sponsors; however, modifications developed by this team have been initiated. These efforts have advanced the current design criteria used in feasibility-level efforts addressing bridge replacement, and provided low cost alternatives that will ensure increased flood carrying capacities in high velocity channels.

*Dr. Jimmy E. Fowler, Cheryl E. Pollock, and Dr. Donald T. Resio* were selected for the award for their development of the Rapidly Installed Breakwater (RIB) system. The RIB system is designed to address problems associated with the military's efforts to off-load ships at sea during Logistics Over the Shore (LOTS) operations. Problems arise with these operations when seas become turbulent, limiting capabilities of crane operators and stevedore crews. The RIB system is designed to solve this problem by creating a "pool" of calmer water where these operations can continue. During the spring and summer of 1996, the capabilities of a mid-scale RIB system were demonstrated during a field deployment. The Joint Integrated Product Team, which coordinates all Joint LOTS-related R&D, has selected the RIB system as one of the top priority efforts for rapid prototyping within DOD.

### **U.S. ARMY MEDICAL RESEARCH AND MATERIEL COMMAND**

#### ***U.S. Army Medical Materiel Development Activity***

*MAJ Tracey L. Syvertson* was chosen for the award for her leadership in organizing and managing a team that developed the Armored Medical Treatment Vehicle. The team was composed of highly skilled and motivated engineers, craftsmen and military medicine operations specialists. Under her direction, this team moved the project from a concept stage through early mock-ups to delivery of a combat-ready prototype in less than 5 months in early 1996.

### **DEPUTY CHIEF OF STAFF FOR PERSONNEL**

#### ***U.S. Army Research Institute For the Behavioral and Social Sciences***

*Dr. Robert A. Wisber* will be recognized for his outstanding research related to training the Individual Ready Reserve (IRR) during mobilization. He led a team of researchers in identifying factors that predict how well critical military skills are retained and reacquired by members of the IRR during mobilization. His efforts led to a change in mobilization policy that has been implemented with the Volunteer for Early Access From the Ready Reserve Program.

### **U.S. ARMY MATERIEL COMMAND**

#### ***U.S. Army Research Laboratory***

*Drs. Louise C. Sengupta and Somnath Sengupta* will be cited for their outstanding research in the use of ferroelectric material instead of ferrite as the phase shifting element for antennas. The new material reduces the cost of each element and reduces the weight of the antenna by 25 percent, making it more accessible to the warfighter. The high-voltage breakdown strength of the ferroelectric material makes it a viable candidate for high energy storage with potential application for the pulsed power supply for the electromagnetic gun.

*Dr. Betsy M. Rice and Dr. Samuel F. Trevino* will be honored for their use of theoretical chemistry to determine a novel mechanism for detonation. They developed and tested a realistic model of an energetic crystal using the atomistic simulation method known as molecular dynamics, and compared the results with those from the well-established hydrodynamic theory of detonation. This effort was the first to confirm that molecular simulation can adequately describe the phenomenon of detonation. Also, Rice and Trevino were the first to provide a microscopic description of the mechanism for steady state detonation, thus providing guidance for performance tailoring of explosives.

*Dr. Anthony E. Finnerty, Dr. Kevin L. McNesby, Dr. Robert G. Daniel, Dr. Andrzej W. Miziolek, Dr. Valeri I. Babushok, Dr. Wing Tsang, and Dr. Robert E. Huie* comprise a team of scientists from the Army Research Laboratory and the Department of Commerce's National Institute of Standards and Technology. This team will be recognized for its significant accomplishments in halon replace-

ment research and for their work on low-temperature water-based agents, the development of state-of-the-art chemical sensor technology for detection of toxic combustion byproducts, uncovering the fundamental mechanisms of flame suppression, and for determining the environmental fate and effects of halon substitutes.

*Hung Nguyen, Joseph Penn, and Teresa Kipp* will be cited for contributions in advancing state-of-the-art technology in high-resolution thermal and visible computer scene simulation. Their R&D efforts with the CREATION model will have significant impact on the systematic development, testing, and evaluation of automatic target recognition algorithms that have a vital role in maintaining Force XXI battlefield information dominance.

*Dr. Thomas B. Bahder* will receive the award for his research in analyzing global positioning system (GPS) timing data and identifying systematic errors. Bahder was instrumental in finding modifications in the "Q-values" used in the Kalman filter at the GPS Master Control Station. Initial measurements based on the improved "Q-values" resulted in a 25 percent improvement to the GPS ephemeris and a 15 percent reduction in GPS range error.

*Dr. Michael Wraback and Dr. Paul Shen* will be recognized for the development of a high-contrast, terahertz bandwidth all-optical modulator based on virtual exciton effects in an anisotropically strained multiple quantum well. The modulation is characterized by a full width at half maximum of 100 femtoseconds and a contrast ratio of 20-to-1. These properties may be employed in the optical encoding of information at terabit rates for secure communications, as well as in efficient optical logic gates, modulators, and saturable absorbers for optical computing, sub-millimeter wave generation, and signal processing applications.

#### ***U.S. Army Armament Research, Development and Engineering Center***

*Dr. Ernest L. Baker and Tan Vuong* were chosen for the award for their work in the advancement of demolition technology. They developed target interaction modeling for anti-concrete warheads and experimentally verified the most accurate warhead concrete attack simulation capability known to date. This extraordinary contribution to demolition technology now allows the development of a family of improved performance anti-concrete warheads producing controlled target responses.



**U.S. Army Aviation Research,  
Development and Engineering  
Center**

*Dr. Mark B. Tischler, Jay W. Fletcher, and Mohammadreza H. Mansur* will be recognized for their outstanding work on the prediction of rotorcraft flight mechanics off-axis coupling. They developed and implemented a 3-pronged approach to solving the coupling problem by employing the complementary features of analysis, experiment, and simulation. The experimental databases they developed are being used by other U.S. and international researchers to validate theoretical model improvements to flight mechanics simulations. In addition, the empirical correction technique they developed has been used by industry engineers on several current development projects to improve off-axis response prediction in flight control design and analysis studies.

*Dr. Francis X. Caradonna* will be honored for his outstanding work on "Integrated Test and Computation Methods for the Development of Advanced Helicopter Rotors." Caradonna has pioneered computational methods that have solved long-standing, high-speed, free-wake and rotor/wake interaction flows. He also devised and executed the necessary rotor experiments for validating these computations. Caradonna then applied these methods to demonstrate the ability to design greatly improved rotors. His work establishes a strong scientific and engineering basis for future development of improved military and civilian rotorcraft.

**U.S. Army Communications-  
Electronics Command Research,  
Development and Engineering  
Center**

*Theodore J. Dzik* is receiving the award for exceptional technical knowledge, management, and leadership in the design and development of a suite of communications protocols critical for horizontal interoperability, seamless Internet communications, and increased mobility on the battlefield. Dzik's achievements have been implemented by Army, Navy, and Marine Corps project managers.

**U.S. Army Edgewood Research,  
Development and Engineering  
Center**

*Bruce W. Jezek and V. James Cannaliato* will be recognized for the planning and execution of developmental efforts to field the XM94 Long Range Biological Standoff Detection System (LRBSDS). The LRBSDS uses Light Detection and

Ranging technology to provide U.S. forces the first biological standoff detection capability. Easily installed onto a UH-60 Blackhawk helicopter, the LRBSDS can detect and track aerosol clouds that are suspected of containing biological agents up to 30 kilometers away. This early detection allows Army commanders to warn personnel to take appropriate protective measures before they are exposed.

*Dr. Tu-chen Cheng* is receiving the award for exceptional scientific achievement in developing enzyme systems for the decontamination of nerve agents, and for using molecular biological techniques to provide the materials necessary for the decontamination of the chemical agents.

**U.S. Army Missile Research,  
Development and Engineering  
Center**

*Dr. Mark J. Bloemer* is recognized for developing a compact optical time delay unit that slows down the propagation speed of an optical pulse by factors of up to 330. The solid state device provides broadband, jitter-free delays for phased array radars and ultra-wideband communications.

*Susan L. Dunbar and Dr. Wayne L. McCowan* will be cited for successful development and flight testing of an autonomous guidance package for the Advanced Precision Airborne Delivery System. The success of this program is a major milestone in development of a capability for the U.S. Army to precisely dispense munitions and sensors or deliver supplies in support of early entry forces.

**U.S. Army Natick Research,  
Development and Engineering  
Center**

*Dr. Phillip W. Gibson* will be recognized for significant advancements in understanding the transfer of heat and moisture through soldiers' clothing. The coupled thermal physiology model developed by Gibson is also being used by W.L. Gore & Associates (makers of Gore-Tex) in a development program aimed at producing more comfortable medical textiles and gloves. For the first time, the transient interactions between the human thermal control system and the behavior of military clothing systems can be accurately simulated using the sophisticated analytical tools Gibson developed.

*Dr. Lynne A. Samuelson* will get the award for two major breakthroughs in the development of new biosensors and novel conducting polymers for soldier protection. Results of this research are being patented. It is anticipated that fur-

ther development of these new technologies will feed into numerous applications including chemical and biological protection, lightweight rechargeable storage batteries, energy dissipaters, stealth coatings, corrosion protection and, ultimately, "wear-able" computers that are directly integrated into the fabric of the soldier's uniform.

**U.S. Army Tank-Automotive  
Research, Development and  
Engineering Center**

*Dr. Robert Karlsen and David Gorsich* will receive the award for integrating new mathematical frameworks into the Army's human visual system models and other models that predict automatic target recognition performance against various countermeasures. Their research incorporated the new theories of multiresolution analysis and wavelet theory into acoustic, thermal and visual signature analysis.

**U.S. Army Test and Evaluation  
Command**

*CW4 John W. Armbrust*, Chief Army Experimental Test Pilot for the Comanche helicopter, will be recognized for outstanding contributions to Comanche's developmental flight test program. Armbrust has served as a member of a government-contractor flight test team and has been directly responsible for improvements in the helicopter's flight symbology, flight controls, and cockpit design. His efforts will lead to a safer and more capable helicopter for the Army.

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*DANIEL C. OIMOEN is employed at the U.S. Army Topographic Engineering Center and is currently on a developmental assignment in the Office of the Assistant Secretary of the Army (RDA). He holds B.S. and M.S. degrees in civil and environmental engineering from the University of Wisconsin-Madison.*

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## Introduction

The Army is facing many challenges now and in the foreseeable future. One of these challenges involves power generation and management. As the Army moves toward a digitized battlefield, the need for portable (battery) power is increasing significantly because more of the soldier's tasks are done electronically. In FY97, the Army spent \$66 million on batteries, which included the cost to power communications-electronics equipment (radios, night vision devices, etc.), vehicles, and aviation and missile systems. The Army currently uses more than 1,500 different battery types to power its electronic devices, and battery usage is projected to grow at least 10 to 15 percent in FY98 and each year thereafter.

Concerned about increasing power demands and battery support costs, GEN Dennis J. Reimer, Chief of Staff of the Army (CSA), issued two directives: reduce the Army's battery costs 50 percent by FY03 and, wherever possible, use rechargeable batteries for all Army training. In response, GEN Johnnie E. Wilson, Commander, U.S. Army Materiel Command (AMC), initiated and chairs Power Sources Summit meetings. Representatives from major Army commands/agencies and field units attend these meetings. The primary goals are to review, coordinate and prioritize the Army's power sources efforts.

The Army Communications-Electronics Command (CECOM), seeking to further improve on and focus the Army's efforts, established the Power Sources Center of Excellence (PSCOE). As part of the PSCOE, a Senior Advisory Council (SAC) was also established. The SAC membership includes AMC, the Army Training and Doctrine Command (TRADOC), Forces Command (FORSCOM), Army Research Laboratory (ARL), Army Research Office (ARO), Army Tank-automotive and Armaments Command (TACOM), and the Soldier Systems Command (SSCOM).

The PSCOE accepted the CSA's challenge to reduce Army battery costs and field improved rechargeable batteries. A number of efforts were already ongoing to reduce battery consumption and support costs such as fielding improved rechargeable batteries, establishing a Department of the Army policy for Army-wide use of rechargeable batteries, and development of a battery standardization policy. Development efforts were initiated to improve performance, reduce weight, and lower the overall cost of batteries, and to

# REDUCING THE ARMY'S BATTERY USAGE AND COSTS

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By Fee Chan Leung and  
Richard Rizzo

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explore alternative power sources and innovative low-power electronics.

## Military Battery Requirements

Batteries used by the military must operate under more extreme conditions than their commercial counterparts. In the civilian commercial community, portable devices such as cell phones and pagers are used where digital relays and phone lines are abundant and rarely operate at temperatures lower than 0 C or higher than 50 C. These devices do not necessarily need to transmit long distances and are capable of using a variety of small, low-cost, low-power batteries. Commercial devices (and their batteries) become obsolete and are replaced every 3 to 5 years, and each next-generation device uses a "different" battery. The consumer's battery can be replaced at a nearby store or simply recharged because AC or DC power is always available.

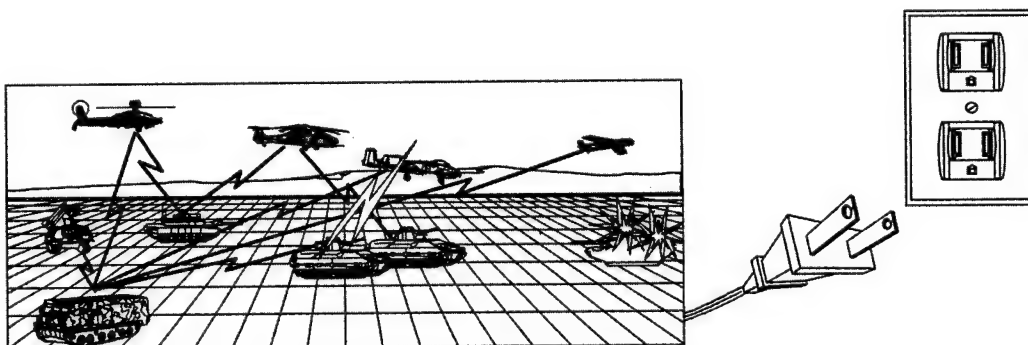
Unlike the civilian community, there are minimal resources on the battlefield to relay voice, data and image transmissions between users. Many portable handheld devices must be able to transmit or relay information to distances of 1 to 3 miles (in

both urban and heavy foliage environments). Military batteries have a minimum power density of 25 watts per pound to meet this capability, where the commercial battery typically has a power density of 5 to 10 watts per pound. Typical military users must be able to operate their equipment in temperature conditions as low as -40 C and as high as 60 C and survive warehouse storage conditions where temperatures cycle between -65 C and 60 C. Lightweight compact batteries capable of high energy and power at extreme military temperatures are critical to modern military forces that rely on electronics to "outshoot, outmove and outcommunicate" their opponents.

To satisfy these demanding requirements, the military must use lithium-based, non-rechargeable batteries for its portable power needs. Lithium systems are used because lithium is a low-cost metal that is lightweight and highly reactive. When this metal is used with other cathode materials, it will produce a battery system that can provide high energy and power per unit weight, operate in extreme hot and cold temperatures, and withstand extreme field storage conditions. The principal military lithium bat-



# The Power Problem



## Where do we get the power we need?

tery system is based on a lithium sulfur dioxide ( $\text{LiSO}_2$ ) chemistry.  $\text{LiSO}_2$  batteries have an energy density of 80 watt-hours per pound and a power density of 25 watts per pound. In addition, the lithium battery operates at temperatures as low as  $-40^\circ\text{C}$  and as high as  $60^\circ\text{C}$ , and has a storage life of 5 years or more.  $\text{LiSO}_2$  battery technology has very limited appeal except for special industrial and military applications. These batteries are not routinely available in the civilian marketplace, and must be procured specifically for military requirements, stockpiled and shipped to users overseas.

### Key Initiatives Overview

The following is an overview of some key initiatives aimed at reducing the Army's battery consumption and support costs.

**State-of-Charge Meter.** Because  $\text{LiSO}_2$  batteries have a flat voltage profile during use, the user cannot determine how much energy remains in a partially used battery by simple voltage measurements. Surveys of disposed batteries conducted in the late 1980s revealed that more than 40 percent of the lithium batteries at disposal sites had at least 70 percent energy still remaining. In response, CECOM fielded the State-of-Charge (SOC) Meter in 1990 to minimize premature disposal of these batteries. The SOC Meter allows

the user to determine the remaining energy content of  $\text{LiSO}_2$  batteries. This allows the user to more accurately decide whether to reuse the battery in training or dispose of it. By maximizing the useful life of the battery, replacement and support costs are reduced substantially.

**Improved Rechargeable Batteries/Rapid Chargers.** CECOM is currently fielding an improved generation of rechargeable batteries to replace the previously fielded lead acid and nickel cadmium rechargeable batteries. These new rechargeable batteries have the potential to reduce the Army's battery costs by 50 percent or more. Since October 1996, the Army has been fielding nickel metal hydride (BB-390/U and BB-388/U) and lithium cobalt dioxide (BB-2847/U) rechargeable batteries. The new nickel metal hydrides possess twice the energy and last twice as long as the older nickel cadmium (BB-590/U and BB-588/U) batteries. The new rechargeable batteries have SOC indicators as a standard feature. These indicators will allow the user to check the batteries to see how much energy still remains and determine if they require charging prior to use.

In the past, the short operating times provided by rechargeable batteries (e.g., 6 hours in an AN/PRC-119 SINCGARS Radio) made their use less practical in military applications. Operational tests of the

new batteries conducted by CECOM and field users showed that the new batteries last significantly longer (e.g., 17 hours in an AN/PRC-119) and have little logistical impact within the units that conducted the tests. Operating times will vary in other devices depending on mission profile.

CECOM is also fielding a new PP-8444 A/U smart charger, which can recharge most batteries in 2 hours. The new rapid charger is designed to charge nickel cadmium, nickel metal hydride and lithium-ion batteries. This charger is an improvement over the older PP-7286/U charger, which takes 10 to 12 hours to recharge batteries. Currently, the new charger is being enhanced to provide forward-area charge-on-the-move in a rugged design mounted on vehicles.

**Rechargeable Battery Implementation Policy.** On Aug. 29, 1997, LTG John G. Coburn, the Army Deputy Chief of Staff for Logistics, signed a policy statement requiring the use of rechargeable batteries in lieu of nonrechargeable batteries for all Army training. The policy becomes fully effective on Oct. 1, 1998. It covers use of rechargeable batteries such as the BB-390A/U, BB-388/U, BB-516 A/U, BB-503 A/U and the BB-2847/U. For further information and guidance on this policy, contact Rafael Casanova, AMC Battery Management Office,

(732) 532-8941, DSN 992-8941, or e-mail: [casanova@doim6.monmouth.army.mil](mailto:casanova@doim6.monmouth.army.mil).

**State-of-Charge Indicator.** Using the lessons learned from the SOC Meter initiative, new lithium batteries being fielded in the current multiyear battery procurement have a built-in SOC indicator. These new lithium batteries have an integrated circuit chip that monitors the amounts of energy being drawn out of the battery. The battery displays the information to the user as a range: 70 to 100 percent; 40 to 70 percent; 10 to 40 percent; 10 percent or less energy remaining. This feature permits the soldier to determine the energy remaining in the battery and thus maximize the use of all the energy prior to its disposal.

### Alternative Technologies

As the use of rechargeable batteries increases, the demand for LiSO<sub>2</sub> primary batteries will decline sharply, thus impacting production base and costs. Currently, the United States barely supports three LiSO<sub>2</sub> manufacturers. CECOM's research and development efforts are aimed at getting the military to transition from reliance on military-specific battery technologies to lower cost, dual-use alternative commercial technologies. Some of these alternative technologies are presented in the following paragraphs.

**Lithium Manganese Dioxide Pouch Cells.** CECOM is developing design concepts that package lithium systems using solid cathodes (such as manganese dioxide) into polymer-lined foil pouches as cell containers in lieu of traditional stainless steel cans. This design concept offers economic and strategic advantages for the military. Commercial lithium manganese dioxide batteries generally use AA or smaller size cells as memory batteries for computers, and flat coin cells for watches, calculators and consumer electronics. The military needs the large high-power cells (C size or larger). The larger cells are more costly because of their size and the lack of commercial demand, and because federal regulations do not permit the transportation of lithium cells larger than AA size on commercial passenger aircraft. This dichotomy of cell sizes forces industry to set up two separate production facilities, one for the commercial consumer and another for the military.

With the future demand for primary military batteries continuing its downward trend, vendors will be hesitant to invest in production lines for military cells. Pouch cells offer the military the potential to maintain the production base that can be sustained by a commer-

cial market. The pouch cell design will afford the manufacturer the ability to set up one production line that can cut both small lithium pouch cells for consumer batteries and the large military lithium pouch cells. Prototype pouch cells can provide 50 percent more energy per unit of weight when compared to current Army LiSO<sub>2</sub> batteries. Successful demonstration of these prototype batteries in the Land Warrior/Force XXI Land Warrior Programs will serve as the basis for inserting pouch cell technology into future Army systems.

**Rechargeable Lithium Polymer Cells.** CECOM is currently working with industry to develop lower cost rechargeable lithium batteries by examining lithium systems that use cheaper materials such as manganese oxide in lieu of cobalt oxides. The lower cost of manganese dioxide and the ability of the material to be packaged in thin foil packets in lieu of the traditional stainless steel can cell has opened new avenues of approach for design and manufacturing.

Prototype pouch cells have demonstrated a 50 percent energy density increase over the current cylindrical cell rechargeable lithium systems. The longer operating times provided by these advanced batteries may allow the use of rechargeable batteries for military use. This capability may improve the lethality of future combat forces. Successful demonstration of this technology in the Land Warrior/Force XXI Land Warrior Programs will serve as a technical basis for future rechargeable battery applications.

**Power Management and Low-Power Electronics.** CECOM recognizes that advances in portable power technologies alone will not produce lightweight and compact electronic devices. The need for equipment developers to consider device power consumption as a critical variable in design and its impact on battery logistics and costs is paramount. Commercial industry has demonstrated that the technology is available to drastically reduce power usage of consumer appliances, and the key to this success was recognizing power management as a critical issue in the design effort. Currently, CECOM is assessing future low-power electronics, smarter integrated circuit designs, and energy-efficient chips that can reduce power usage by 80 percent or more in future circuits. Many of these technologies and designs are being developed by academic institutions and private companies funded by the Defense Advanced Research Projects Agency. CECOM will transition these new technologies from the bench to advanced field demonstrations and ulti-

mately into future Army electronic devices.

### Conclusion

The Army has initiated aggressive efforts to improve power sources technology and reduce battery usage and support costs. To reduce battery-type proliferation and the associated costs, the Army Acquisition Executive signed a policy memorandum on Oct. 17, 1996, entitled Power Sources Management. This policy requires the use of Army standard batteries, employment of power management techniques, and the coordination of all battery requirements with the PSCOE. This policy applies to all new and ongoing programs, including product improvement programs and technical insertion efforts. In concert with this policy, the PSCOE has developed a Power Sources Statement of Work (PSSOW) for use in all contracting efforts. The PSSOW contains guidance on battery selection, a list of approved batteries for use by the Army, and power management requirements.

If you have any questions on the information presented in this article or on other power-related efforts, contact Thomas Nycz, Chief of the AMC Battery Management Office, at (732) 532-8984, DSN 992-8984, or e-mail: [nycz@doim6.monmouth.army.mil](mailto:nycz@doim6.monmouth.army.mil). Questions pertaining to technical issues can be directed to Dr. Robert P. Hamlen at the CECOM Research, Development and Engineering Center at (732) 427-2084, DSN 987-2084, or email: [hamlen@doim6.monmouth.army.mil](mailto:hamlen@doim6.monmouth.army.mil).

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*RICHARD RIZZO is employed in the AMC Battery Management Office. He has a B.S.E.E. degree from Norwich University and an M.S.E.E. degree from Fairleigh Dickinson University.*

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# ARMY ACQUISITION CORPS OFFICER MANAGEMENT XXI

By COL Ronald C. Flom

*Author's Note: Unless otherwise designated, use of the term PM in the following article is inclusive of program manager, project manager, and product manager.*

## Introduction

The Army Acquisition Corps (AAC) was formally established more than 8 years ago. Since that time, the Army and its officer corps have been impacted by some major events and changes that have also affected the AAC itself: Desert Shield/Desert Storm, military downsizing, large decreases in Defense spending, downsizing of the AAC, creation of a new Officer Evaluation Report and, more recently, development of the Officer Personnel Management System (OPMS) XXI.

During this transitional period, the Army has learned a lot about how to manage and professionally develop AAC officers. In retrospect, some things were done right and, frankly, some things could have been done better.

What follows describes the officer management system currently in place for AAC officers and how the Army and the Director, Acquisition Career Management have poised the AAC for the 21st century.

## Background

Army officers have been heavily engaged in the development and acquisition of weapons, goods, and services for our Armed Forces since the very beginning of our nation. More recently, increasing costs of major weapon systems and ballooning federal budget deficits have caused the Army to evaluate not only how it develops and acquires major weapon systems, but how it acquires and develops the officers who perform these functions.

Under OPMS II, the Army had three functional areas (FAs) related to systems acquisition and procurement: FA51 (Research, Development and Acquisition); FA53 (Systems Automation); and FA97 (Contracting and Industrial Management). Prior to and during the early 1980s, the Army had a somewhat informal system of developing acquisition officers called the Project Management Development Program. It was commonly known as the "6T" Program because of the special skill identifier that officers in the program received.

The rapid increase in major weapon

systems development and acquisition during the Reagan administration caused the Army to re-evaluate the education, training, and career development of officers in the 6T Program. What resulted in the mid-1980s was the establishment of the Materiel Acquisition Management (MAM) Program and some needed changes to the education and training criteria for acquisition officers.

## Defense Acquisition Workforce Improvement Act And The AAC

Some well-publicized acquisition "nightmares" during the Reagan buildup and the findings and recommendations of the Packard Commission started a chain of events that resulted in Congress passing the Defense Acquisition Workforce Improvement Act (DAWIA), codified in Title X of the United States Code. The purpose of DAWIA was to establish uniform policies and procedures throughout the Department of Defense (DOD) to effectively manage officers and civilians in DOD acquisition positions. Those policies and procedures governing accession, education, training, and career development were designed to "professionalize" the Acquisition Workforce.

The establishment of the officer component of the AAC was well under way. In early 1990, about 2,500 of the 6,000 officers in FAs 51, 53 and 97 were accessioned into the AAC. Most of FA97 was initially excluded from the AAC because contracting commands were outside the AAC; this situation was corrected in 1991.

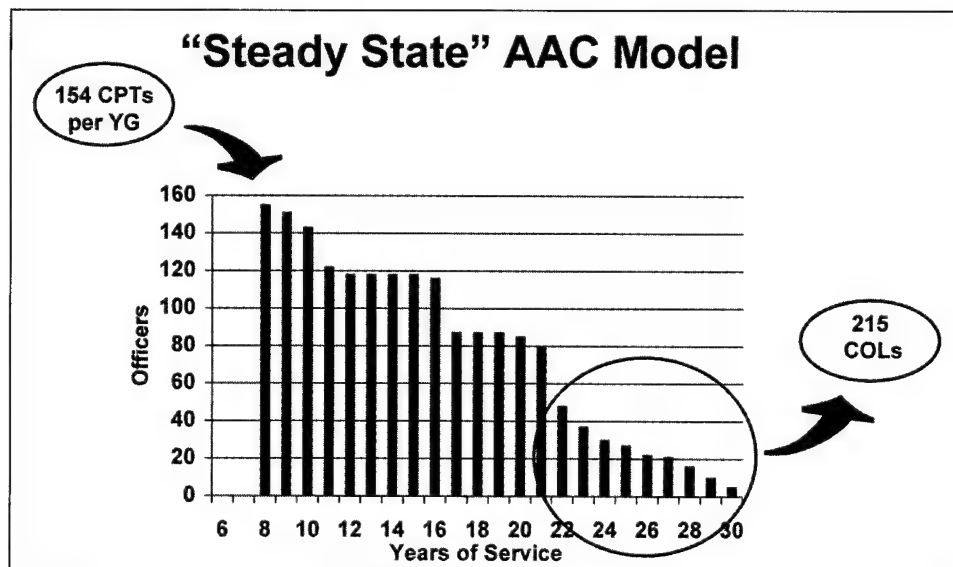


Figure 1.

# MAJ Promotion Results

## Primary Zone

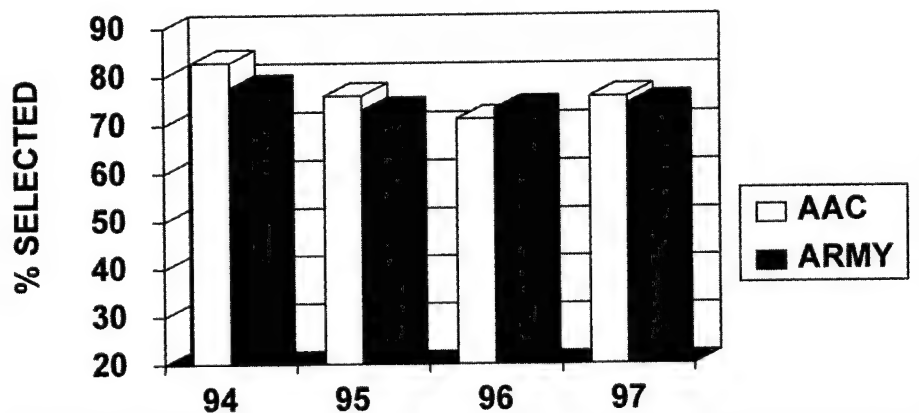


Figure 2.

### Downsizing

Although the downsizing of the Army that occurred during the early 1990s was larger than initially anticipated, the number of AAC officers remained stable at about 2,500. Realizing that the AAC was larger than the downsized Army could support, a decision was made in early 1994 to reduce annual accessions of captains into the AAC from 194 to 154. Based on the model used to size the AAC, accession of 154 officers in their 7th year produces a steady state total of 215 colonels and an AAC of approximately 2,000 officers, as shown in Figure 1.

The decision to reduce only accessions left the AAC with more colonels, lieutenant colonels, and majors than were supported by requirements. Since the promotion system is based on requirements, the days of above average promotion rates for AAC officers were about to come to an abrupt halt.

With this in mind, the Army Chief of Staff approved a plan on Aug. 30, 1996, to downsize the AAC. To execute the plan, the Military Acquisition Management Branch (MAMB) at the U.S. Total Army Personnel Command (PERSCOM) had to identify 186 lieutenant colonels and majors to return to their basic branch or otherwise leave the AAC. The goal was to reduce the size of the AAC through voluntary means (voluntary transfers back to

basic branch, retirements, separations, etc.) if possible. About 60 percent of the requirement was met through volunteers. However, two transfer boards were required to reduce the AAC to the right size and position it to level out at 2,000 officers by the year 2000.

### OPMS XXI Impact On The AAC

The drawdown of the Army officer corps, changes in Army structure, and other factors caused the Army to reengineer officer personnel management. OPMS XXI structures the officer corps into four career fields. The AAC is in the Operational Support Career Field. OPMS XXI is now being implemented throughout the Army.

One change OPMS XXI creates is the career field designation process. The AAC will continue to access officers in their 7th year of service. When selected for promotion to major, AAC officers will be designated into the Operational Support Career Field.

Another key provision of OPMS XXI is requirements-based promotions by career field. Since the AAC will retain its requirements-based promotion system, there should be no significant change to AAC promotion opportunities.

Under OPMS XXI, all centrally selected commands will be filled by officers from the Operations Career Field. This also will not impact the AAC because

the central selection system for project/product managers and acquisition commanders (ACs) will be retained.

### Acquisition Officer Leader Development

The remainder of this article focuses on acquisition officer leader development. Leader development is an iterative process that changes over time. The current process "grows" future senior acquisition leaders to fill critical acquisition positions. The Leader Development Model was jointly developed by the Acquisition Career Management Office and MAMB. It can be viewed on the AAC home page at <http://www.dacm.sarda.army.mil>.

Acquisition officer certification is an important topic when acquisition leader development is discussed. Because of the complexity of certification requirements across the spectrum of civilian and military acquisition career fields, certification is not discussed in detail in this article.

### Accession

Captains are accessed into the AAC during their 7th year of service. An AAC Accession Board met in March of this year and accessed Year Group (YG) 91. Officers are accessed from all branches in the Army Competitive Category (combat arms, combat support, and combat service support). Each branch provides a fair share from a particular YG. Currently, 154 officers are accessed into the AAC from each YG. Captains accessed during their 7th year are generally available for reassignment to their first acquisition job or training during their 8th year.

### Education/Training

One of the first things evaluated on newly accessed officers is education. Officers who already have an acquisition-related advanced degree can be sent to the Materiel Acquisition Management Course or Systems Automation Course, or receive other training and then proceed to their first acquisition assignment.

Officers who do not have an acquisition-related advanced degree generally follow the same path, but are also considered for fully funded advanced civil schooling (ACS), or other degree producing programs. Fully funded ACS quotas are currently limited to 65 annu-



ally. These AAC advanced degree programs are currently 12 to 18 months in length.

Another opportunity for AAC officers is Training With Industry (TWI). Currently, 10 officers are sent annually to TWI with Defense contractors who build major systems or provide services to the Army.

Throughout their acquisition career, officers will also be afforded the opportunity to attend training required for the three levels of DAWIA certification. As a senior major or lieutenant colonel, most AAC officers will be scheduled to attend the Advanced Program Manager's Course (APMC) at the Defense Systems Management College. One of the prerequisites for APMC attendance is completion of the Command and Staff College (CSC).

### Promotion To Major

Officers are promoted to major based on what they have accomplished in their basic branch, not generally what they have done in the AAC, because most captains in the zone of consideration are still in their first acquisition assignment. Therefore, what gets an officer promoted in the AAC is no different from what gets an officer promoted elsewhere in the Army—a strong file with successful company command. Selection rates of AAC officers to major have been above the Army average each year except FY96, as shown in Figure 2.

Once selected for major, acquisition officers compete for selection to CSC. Acquisition officers will be selected for resident CSC at the same rate as the rest of the Army, currently 50 percent of a year group. Each officer receives four considerations for CSC. The greatest opportunity for selection is during the first two evaluations. Officers not selected for resident CSC after the second look should enroll in the non-resident course to complete CSC and be awarded Military Education Level 4 prior to consideration for lieutenant colonel. A major who does not complete CSC will not be promoted.

### 'Branch Qualification' As A Major

There is no magic formula for an officer to become branch qualified in the AAC as a major because, by definition, all Military Acquisition Position List (MAPL) jobs are "branch qualifying."

We have learned through experience

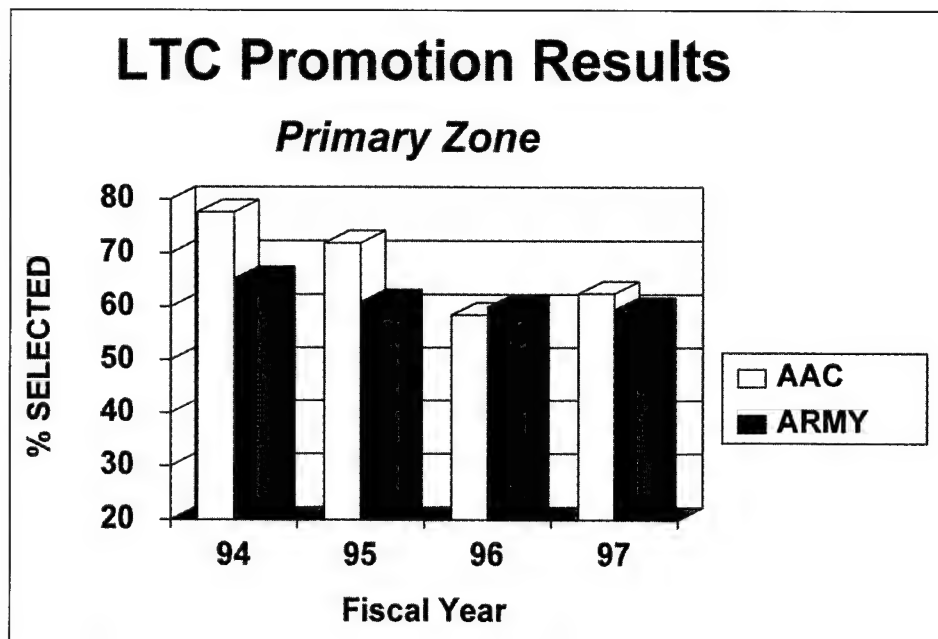


Figure 3.

that officers who are most competitive for product manager or acquisition command have served in a variety of jobs as a major. For example, an FA51 officer should serve in a PM office, but should also do other things such as combat development with the U.S. Army Training and Doctrine Command, or testing with the U.S. Army Operational Test and Evaluation Command or the U.S. Army Test and Evaluation Command to broaden his or her experience. Similar broad-based experience is necessary for FA53 or FA97 officers.

Assignment officers in MAMB know what jobs make an individual competitive for PM or AC assignments. The size and composition of the MAPL changes from year to year. Those changes directly affect the Career Development Model and the path for a successful career. Career managers at PERSCOM are very knowledgeable about those changes. Rely on their expertise when plotting the path to career goals.

### Promotion To Lieutenant Colonel

Majors with continuing high levels of performance and strong overall files will be selected for promotion to lieutenant colonel. Officers must have completed CSC (either resident or non-resident) if they hope to be competitive for lieutenant colonel. Selection rates to lieutenant colonel for AAC officers have been above the Army average each

year except FY96, as shown in Figure 3.

### Lieutenant Colonel Product Manager Or Acquisition Commander

Officers with overall strong performance trends and broad-based experience will be competitive for selection to product manager/acquisition commander as a lieutenant colonel. Being equivalent to battalion command for AAC officers, selection as a PM/AC is a strong indicator that an officer has the potential to be one of the future AAC senior leaders. For at least the past few years, overall selection opportunity for AAC officers to PM/AC has been competitive with or slightly higher than battalion command selection for the rest of the Army.

If an officer is selected as a PM or AC, MAMB will slate that officer to the appropriate product manager or AC position based on acquisition experience, technical qualifications and, in some cases, basic branch affiliation.

Unlike 2-year battalion command tours, centrally selected PM and AC tours generally last 3 years because they are also acquisition-critical positions.

Officers who are high alternates on the PM/AC list are likely to be activated for PM or AC once the senior service college (SSC) list is released a few months later because of tour curtailments of serving product managers and ACs.

## Senior Service College

Successful product managers and ACs compete for 30 AAC seats in the SSC each year. Because of the 3-year tour length for PM/AC, about one-half of the AAC officers selected for SSC each year are reassigned from PM/AC tours at less than 3 years. If selected, an officer should plan to attend the next academic year. Because the seats are reserved for the AAC, every officer who does not attend (for whatever reason) costs the AAC a seat. For example, there are 23 AAC students in current SSC classes of the 30 originally selected.

Acquisition officers attend the Army War College, the Industrial College of the Armed Forces (ICAF), or the Acquisition SSC Fellowship at the University of Texas (UT). The AAC receives eight seats for ICAF and three for the SSC Fellowship at UT each year. Because of the requirements of the Goldwater-Nichols Act, AAC officers attending ICAF should expect to go to a joint assignment after graduation. Officers who are already joint specialty officers cannot attend ICAF.

## Promotion To Colonel

Lieutenant colonels who have been successful product managers or ACs and have completed SSC (resident or non-resident) should be competitive for promotion to colonel. However, with an Army average selection rate for colonel of about 40 percent, some officers who completed successful PM/AC tours will not be promoted to colonel. Selection rates to colonel for AAC offi-

cers fell well below the Army average in FY96, but recovered much lost ground in FY97, as shown in Figure 4. The AAC appears to be positioned to return to above Army average selection rates to colonel this year.

## Colonel Project Manager/Acquisition Command

Because of the large number of colonel-level project manager and AC positions, AAC officers promoted to colonel have a better than 50-50 chance of being selected for project manager or AC. Being equivalent to brigade command for AAC officers, PM/AC selection indicates that an officer is now a bonafide senior leader in the Acquisition Corps. For at least the last few years, overall selection opportunity for AAC officers to PM/AC is much higher than brigade command selection opportunity for the rest of the Army.

As is the case with lieutenant colonel slating, MAMB will slate colonels to the appropriate project manager or AC position based on acquisition experience, technical qualifications and, in some cases, basic branch affiliation. Colonel-level PM/AC tours are also 3 years and, for some project managers, 4 years in length.

## Life After PM/AC

For colonels who are successful, there is life after being a project manager or AC. A very small number (three to five per year) will be selected for brigadier general. All former PMs/ACs can expect

to go to those jobs that require the most experienced, technically qualified, and highly competitive AAC colonels.

## Conclusion

The actions that have occurred during the 8-year life of the AAC have created a flexible corps of acquisition professionals who are prepared for the next century. Some future initiatives to keep the AAC current are as follows:

- A single functional area to provide greater flexibility in developing and assigning AAC officers;
- Increased emphasis on digitization and modeling and simulation to provide a strong force multiplier for the Army After Next; and
- Additional opportunities for acquisition officers to maintain their roots with the operational force and their basic branches to enhance AAC officer awareness of the reason we are all here.

The leadership of the AAC and MAMB have worked hard to build a highly effective AAC. The results of those efforts are seen in selection board rates. Continuing competitive promotion and school selections, and a high percentage of first-time selections for PM/AC assignments demonstrate that we are doing a good job in acquisition leader development.

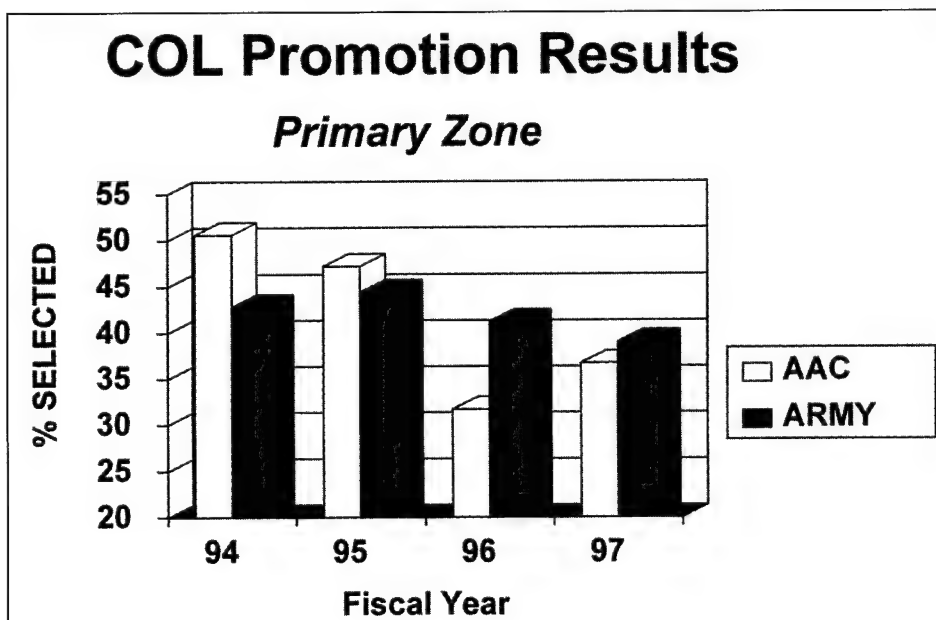


Figure 4.

*COL RONALD C. FLOM is the Commander of Defense Contract Management Command Baltimore. He was Chief of the Military Acquisition Management Branch at the U.S. Total Army Personnel Command when he wrote this article. He holds a B.A. degree in political science from the University of North Dakota, and M.S. degrees in contract and acquisition management from Florida Institute of Technology and in national resources strategy from National Defense University. COL Flom is a graduate of the Program Manager's Course at the Defense Systems Management College, the Industrial College of the Armed Forces, and the Senior Acquisition Course at Defense Acquisition University.*



# OUTSTANDING ACHIEVEMENTS IN MATERIEL ACQUISITION

Dr. James Edgar and  
Elizabeth Ratliff



*The silver medallion presented to recipients of the Army Award for Outstanding Achievement in Materiel Acquisition.*

## Introduction

Secretary of the Army Awards for Outstanding Achievement in Materiel Acquisition for FY96 were presented in February to four teams and two individuals. Dr. Kenneth J. Oscar, Acting Assistant Secretary of the Army for Research, Development and Acquisition (ASARDA) made the presentations during ceremonies at Fort Monmouth, NJ, and Natick, MA.

Authorized by the Secretary of the Army in AR 672-20, the awards are given annually for outstanding individual or team contributions to the timely, efficient, and economical acquisition of quality supplies and services. Specifically, the awards recognize high-level achievements in project, materiel, and special management activities; procurement and production efforts; and management of research and development projects. The award consists of a

silver medallion, lapel pin, and a citation certificate, DA Form 7129 (Secretary of the Army Award for Outstanding Achievement in Materiel Acquisition) signed by the Secretary of the Army.

## Historic Background

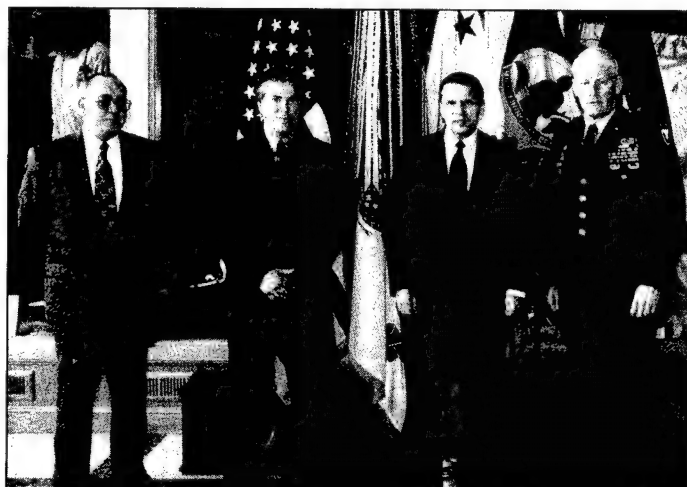
Considered the most prestigious acquisition award in the Army, the Materiel Acquisition Award was established in the early 1970s and is the Army's counterpart to DOD's David Packard Award. The Materiel Acquisition Award honors Henry Knox, a native Bostonian and one of the heroes of the American Revolution. Knox joined a local military company at age 18 and was present at the Boston Massacre. He joined the Boston Grenadier Corps in 1772 and offered his services to General Washington in 1775. Commissioned a colonel in the Continental Regiment of

Artillery, he led the expedition to transfer captured British guns from Fort Ticonderoga to Boston in 1776. Knox also led the Delaware River crossing and participated in the Battle of Trenton in 1776 and was promoted to brigadier general and Chief of Artillery of the Continental Army in December 1776. In addition, he participated in the battles of Princeton, Brandywine, and Germantown in 1777 and Monmouth in 1778. Knox placed the American artillery at the Yorktown siege in 1781.

Knox served under the Confederation as Secretary at War from March 8, 1785, to Sept. 11, 1789. Under the Constitution of the United States, Knox served as the first Secretary of War from Sept. 12, 1789, until Dec. 31, 1794. At that time, the position of the Secretary of War was similar to the current Secretary of Defense position because there was no separate Navy Department. Knox organized the War Department, which consisted of himself and one clerk. He also prepared a plan for a national militia, advocated and presided over initial moves to establish a regular navy, and initiated the establishment of a chain of coastal fortifications.

In 1776, Knox called for the founding of a capital laboratory for the manufacture and storage of arms and ammunition. With Washington's endorsement, the Continental Congress approved the recommendation and the first of the new ordnance depots was established at Carlisle, PA. This reflects the traditional role of the Secretary of the Army in supervising procurement and acquisition that was initially established by the

(Left to right)  
Jimmy Hodges  
and Robert G.  
Bernazzani, two  
of three members  
of the Mounted  
Water Ration  
Heater IPT;  
Dr. Kenneth J.  
Oscar, Acting  
ASA(RDA); and  
BG Robert L.  
Floyd II,  
Commander, U.S.  
Army Soldier  
Systems  
Command.



Continental Congress. Under President Washington and Secretary Knox, the arsenal system, which is the foundation for the Army's acquisition system, began with the manufacture and stockpiling of weapons. It is most appropriate that the Army's premier acquisition award is named for Henry Knox.

### Award Eligibility

All direct-hire Army civilian and active duty personnel are eligible for consideration for the Materiel Acquisition Award. A maximum of 10 awards (to individuals and teams) may be presented annually. To be eligible for the award, individuals or teams must have been assigned for duty in a staff or operating function in support of the materiel acquisition process for at least 1 year prior to the expiration of the period of service to be recognized, and make a significant contribution to improving the materiel acquisition process.

Four criteria are considered in evaluating materiel acquisition achievements: the complexity of the problem involved and the degree of initiative and originality displayed in solving it; the relative significance of the accomplishment in light of the overall activity mission; the possibility of direct application or adoption of the contribution by other activities; and the improvement in program management.

### FY96 Team Recipients

The four team awards for FY96 were presented to a team from the Soldier Systems Command (SSCOM), Natick, MA, and three teams from the Communications-Electronics Command (CECOM) at Fort

Monmouth, NJ. The composition and accomplishments of these teams are described below.

The Mounted Water Ration Heater (MWRH) Integrated Product Team (IPT) from the SSCOM was recognized for its exceptional accomplishments in planning, leading, and executing acquisition and fielding of the MWRH. The team's dedication to improving the quality of life for the individual soldier and its commitment to the success of this program resulted in type classification of the MWRH in only 9 months, following approval and funding of the project. By advocating the principles of acquisition reform, the team provided an excellent product at a cost savings to the government of more than \$2.2 million. Members of the MWRH IPT are Jimmy Hodges, Office of the PM-Soldier, SSCOM, Fort Belvoir, VA; Robert G. Bernazzani, Sustainability Directorate, Natick Research, Development and Engineering (RDE) Center, SSCOM, Natick, MA; and Larry T. Hasty, Directorate of Force Development, U.S. Army Armor Center, Fort Knox, KY.

The Command, Control, Communications, Computers, Intelligence, Electronic Warfare and Sensors (C4IEWS) Specifications and Standards Acquisition Reform (SSAR) Team from CECOM developed a master action plan in support of acquisition process reform. The plan emphasizes training the workforce to reduce acquisition lead times; maximizing efficiency in the acquisition process; producing high-quality products and services; and reducing costs for improved products and services. Their

accomplishments are quickly making Team C4IEWS the most intelligent and responsive buyer of the best, most cost-effective products and services that meet the warfighters' needs. Members of the C4IEWS SSAR Team are Emerson W. Ellett, Staff Logistician for the Program Executive Office (PEO) for IEWS; Charles M. Cebula, Electrical Engineer for the PEO, Command, Control and Communications Systems; Stephen H. Kurzer, Electronics Engineer for the Night Vision and Electronic Sensors Directorate, CECOM RDE Center; David Leciston, Computer Scientist for the Software Engineering Center; and Latonya A. Jackson, Program Assistant for the Logistics and Readiness Center.

The Joint Tactical Terminal/Common Integrated Broadcast Service Modules (JTT/CIBSM) Source Selection Team from the PEO-IEWS, performed an exceptional source selection of the JTT/CIBSM during FY96. The team incorporated current DOD and Army acquisition streamlining initiatives, lessons learned from recent streamlined acquisitions and commercial practices; and tailored existing acquisition practices to achieve a dramatic reduction in the time, effort, cost, and documentation required to award a contract for the technically complex JTT/CIBSM. This acquisition is expected to serve as a model for future procurements. Members of the JTT/CIBSM Team are Kenneth R. Kraus, PM Joint Stars System Engineering Division Chief; John C. Quinn, Project Leader, Joint Stars JTT; Thomas D. Carroll, CECOM Legal Office Attorney-Advisor



(Left to Right) Dr. Kenneth J. Oscar, Acting ASA(RDA), with three of five members of the Command, Control, Communications, Computers, Intelligence, Electronic Warfare and Sensors Specifications and Standards Acquisition Reform Team: Charles M. Cebula, Stephen H. Kurzer, and Latonya Jackson.



Four of five members of the Joint Tactical Terminal/Common Integrated Broadcast Service Modules Source Selection Team (left to right): Arnold A. Rappaport (who received an individual award for his efforts in supporting this team), Kenneth R. Kraus, Thomas D. Carroll, and Stephen J. Morton.

Three of four members of the Battlefield Combat Identification System Team (from left to right): John A. Kwiecien, James Steinberger, and George A. Tanner.



(Contracts); and Stephen J. Morton, Deputy Product Manager for JTT/Commander's Tactical Team.

The Battlefield Combat Identification Systems (BCIS) Team from the PEO-IEWS, designed, directed, and evaluated a study on cost as an independent variable. The purpose of the study was to evaluate performance/cost/schedule trades and producibility enhancements to the baseline BCIS system. The study resulted in a production unit cost savings of \$35 million with no reduction in critical performance areas. The core and matrix members of the BCIS Team are Martha Faralla, PM; John Kwiecien, Systems Engineer; James Steinberger, Business Manager; and George Tanner, Production Engineer.

### FY96 Individual Recipients

The FY96 Materiel Acquisition Awards for individuals were presented to two CECOM employees at Fort Monmouth, NJ. The recipients and their achievements are described below.

Arnold A. Rappaport received the award for his outstanding performance as the CECOM acquisition leader in the successful planning and execution of the 1996 JTT/Common Integrated Broadcast Service Module 10-year procurement in support of the Army, Navy, Marine Corps, Air Force, and Special Operations Forces. Rappaport's guidance and leadership were crucial in implementing several new techniques in the contract placement process. Most noteworthy were cost tradeoffs for affordability, streamlining of acquisition planning documentation, and the use of signed offers in lieu of written proposals. His vigorous approach to acquisition streamlining and reform resulted in a significant advancement in

the Best Value acquisition process.

Ronald Schaefer from the PEO-IEWS, received the award for his outstanding achievement in materiel acquisition for the Army Common Ground Station, Medium Ground Station, and Light Ground Station Modules. Schaefer was cited for his initiative and aggressive approach to acquisition reform, and for his knowledge of the Joint Surveillance Target Attack Radar System (STARS) Program. Schaefer was also recognized for successful program and technical decisions, for directing and using the matrix support of more than 25 staff members, and providing outstanding recommendations to the Joint STARS PM.

### Conclusion

In February 1997, the Assistant Secretary of the Army (Manpower and Reserve



Ronald Schaefer, recipient of an individual Materiel Acquisition Award.

Affairs) transferred administration of the Materiel Acquisition Award from the Army Incentive Awards Board to the ASARDA. An effort is currently under way to integrate the award with other existing acquisition awards, such as the PM of the Year Award, and the Secretary of the Army Awards for Excellence in Contracting. It is anticipated that this may result in a 70-series publication governing all acquisition awards. Nonetheless, the Secretary of the Army Award for Outstanding Achievement in Materiel Acquisition will remain the premier acquisition award within the Department of the Army.

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*ELIZABETH RATLIFF is a procurement analyst at Headquarters, U.S. Army Space and Missile Defense Command, Huntsville, AL. Currently on a 1-year developmental assignment in the Office of the Deputy Assistant Secretary of the Army (Procurement), she has an A.A. degree in business administration; a B.S. degree in manpower, industrial relations and organizational behavior; and an M.B.A. degree.*

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# MODELING AND SIMULATION IN SUPPORT OF TEST AND EVALUATION

## Introduction

The end of the Cold War has brought about many global changes. Clearly, we no longer require the Defense structure that we needed in the past. It is also clear, however, that we need a force structured to execute an effective security strategy. One key factor affecting the ability to accomplish this is the considerable reduction in Defense resources that has resulted in drastic downsizing and restructuring of the military. It has greatly curtailed training and large-scale deployments, which means fewer opportunities for driving tanks, sailing ships, and flying airplanes. Thus, it is difficult for soldiers to gain the warfighting skills required to effectively use our new force structure.

To deal with these issues, the Department of Defense leadership has implemented many initiatives to reduce Defense costs, while attempting to maintain combat readiness. One of these initiatives is simulation-based acquisition (SBA). SBA urges program managers (PMs) and other acquisition personnel to insert modeling and simulation (M&S) technology upfront and throughout the life cycle of an acquisition program. This will allow for implementation and execution in a systematic, holistic, and consistent manner. This initiative is supported by the Director, Operational Test and Evaluation, Office of the Secretary of Defense, who advocates a "Cradle to Grave" approach (Figure 1).

Historically, developers have partially met this objective by using M&S upfront to explore concepts for systems. They have also effectively used M&S to develop first-class simulations, simulators, trainers, and training centers. The void has been in the area of testing and evaluation (T&E).

The Army's Simulation, Training and Instrumentation Command (STRICOM) has taken the lead in filling this void. STRICOM's PM for the Combined Arms Assessment Network is currently managing the M2A3 Bradley Synthetic Environment Live-Fire Test Program (SELF), which is exploring how M&S can be used to augment T&E. This article provides an overview of this program.

## M2A3 Bradley SELF

STRICOM is attempting to demonstrate that M&S can augment live-fire testing (LFT) through the SELF Program of the Office of the Secretary of Defense for Live Fire Test and Evaluation (OSD/LFT&E).

By MAJ Tony F. Hodge

OSD/LFT&E is executing its SELF Program parallel to the PM-Bradley's Live Fire Program. Realizing that the synthetic environment (SE) will never replace LFT, the OSD/LFT&E goal is to augment the data collected by providing insight into future test events and by providing an infrastructure in which variables are introduced on a noninterference basis. The focus is to explore SE approaches for lethality issues and use the M2A3 Bradley development to illustrate the opportunities. The M2A3 Bradley was selected because of the nature of its upgrades. The upgrades do not change the gun or the type of round used. This makes the ability to acquire a target and generate a fire control solution testable in the SE.

## SELF Program Phases

STRICOM is executing the SELF Program in two phases. The first phase, completed in July 1997, involved requirement definition of SE support of LFT and produced two products: a feasibility analysis study (FAS) and a test plan. The FAS identified the requirements to be tested and the methodology to implement and categorize these requirements, identified an infrastructure analysis, and made recommendations to provide SE support of LFT.

In conducting the FAS, the SELF Program team did a two-step measure of performance (MOP) analysis. The first step was an evaluation of the degree to which each MOP addressed LFT. The second step classified the MOPs in terms of their supporta-

bility in the SE. MOPs with a live-fire-test relevance score greater than zero and a supportability score greater than one were selected for evaluation.

The MOP analysis identified 104 MOPs that were testable in the SE. The Army's Operational Test and Evaluation Command (OPTEC) provided the original 407 MOPs from the Bradley System Evaluation Plan (Figure 2).

Phase two of the program, which began in August 1997, consists of SE infrastructure enhancements and test execution. The primary infrastructure enhancements are integration of the latest M2A3 Bradley software into the Bradley Advanced Training System (BATS); integration of the Army's Materiel Systems Analysis Activity (AMSAA) error algorithms and ballistic missiles; use of the Night Vision and Electronic Sensors Directorate (NVESD) Paint the Night (PTN) textile files; integration of synthetic flat panel targets; and modification of the instructor operator station (IOS). Test execution will consist of Limited User Test (LUT) 1 and LUT 2, and initial operational test and evaluation. STRICOM is executing this program in close coordination with the test community, and hosted its first SELF integrated product team (IPT) meeting in Orlando, FL, on Oct. 2-3, 1997. The purpose was to define IPT roles and responsibilities, and to conduct detailed planning for LUT 1.

## LUT 1

The SELF Program Team successfully completed LUT 1 Nov. 21, 1997, and LUT 1 was executed on the BATS at Fort Benning, GA. The BATS is the M2A3 Bradley simulator currently being developed parallel to the tactical vehicle. The SELF LUT 1 replicated gunnery exercises for the M2A3 Bradley LUT 1 Dec. 1-12, 1997. Data were collected to satisfy 30 MOPs that focused on the ability of the M2A3 Bradley to perform target acquisition and delivery accuracy.

The BATS was the vehicle chosen for the tests because its crew station and software are representative of the M2A3 Bradley. The BATS is a complete gunnery training system that consists of a high fidelity gunner and commander's weapon station, and an IOS to control gunnery exercises and provide after action reports.

The BATS also uses a visual and computational system to provide the required images to develop and sustain gunnery

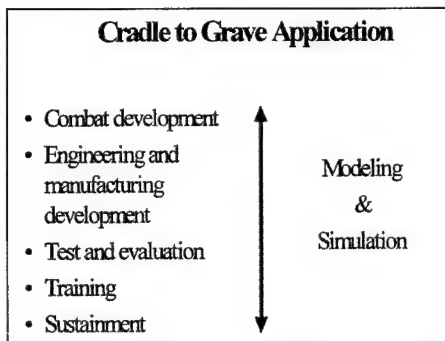


Figure 1.



# MOP ANALYSIS

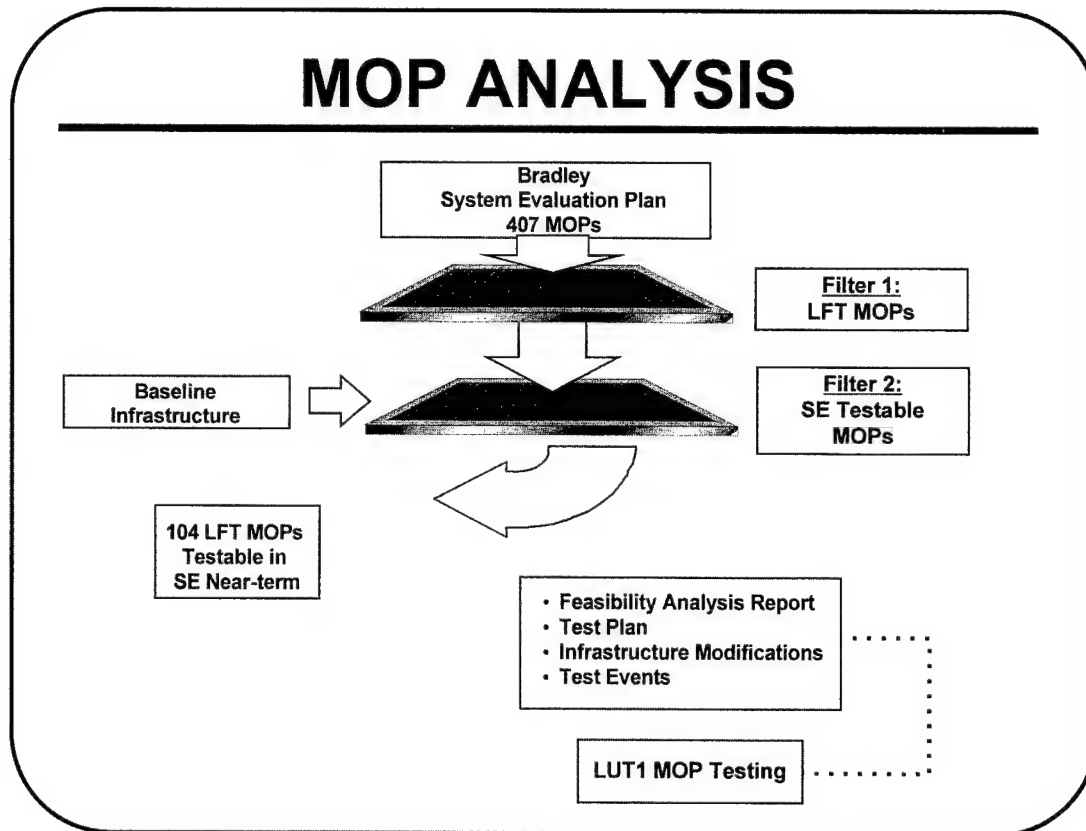


Figure 2.

skills for the Bradley crews. The computational system also uses tactical software that closely replicates actual fire control functions and capabilities of the M2A3 Bradley. The BATS was developed as a prototype trainer to train the trainers and crews to support the Bradley LUT 1.

The M2A3 Bradley LUT 1 live gunnery exercises were conducted at Hastings Range, Fort Benning, GA. To replicate the targets on Hastings Range, the SELF Program Team integrated synthetic flat target representations similar to the panel targets used at the range. These targets were incorporated into the BATS visual system along with the AMSAA ballistic models. This provided the BATS a higher fidelity fly-out simulation and error modeling.

STRICOM intends to explore using NVESD-PTN for second-generation forward-looking infrared representation for future tests. AMSAA algorithms were implemented into the BATS software although the M2A3 Bradley Software Solution provides for tilt error correction and environmental parameters. In addition, three different round dispersion tables were used throughout testing. These tables generated a random dispersion of shots based on the first shot. The Simulation Analyzer (Simulyzer) was used to collect distributed interactive simulation protocol data units (PDUs) on the network. These PDUs provided information such as shot, hit, and kill statistics;

intervisibility over time; an engagement timeline; and vehicle information. The Simulyzer displayed the data being collected in graphical displays during the verification and validation (V&V) and SELF LUT 1 exercises.

AMSAA conducted the V&V of SELF hardware and software integration. STRICOM is closely coordinating with AMSAA to generate a report that documents the results of the V&V. This report will document any discrepancies that might affect the data collected during SELF LUT 1.

Tests consisted of M2A3 Bradley-trained crews executing a series of scenarios that required target detection and engagement. These day and night engagements were developed to generate the data necessary to satisfy MOPs concerning target acquisition, target tracking, and delivery accuracy of rounds. These scenarios allowed the test team to evaluate how well the vehicle under test meets the requirements stated in the M2A3 Bradley MOP. Visiting test personnel also noted that this system captured some relevant data, which is not always possible in the field. It also provided a more controlled environment to assess the system under test.

STRICOM has completed and submitted a SELF LUT 1 test data report (TDR) to OPTEC. OPTEC will review the TDR and databases and generate a SELF system analysis. This analysis will be used to determine future program direction.

## Conclusion

STRICOM has clearly set the pace in attempting to fill the Army's void of augmenting T&E with M&S. Through its SELF Program, STRICOM is demonstrating how T&E and M&S are intertwined, and is well on its way to achieving the objectives of providing testers with a tool set to collect and analyze data in support of future testing and identifying testing issues linking the simulation, test and evaluation process with SBA, for developmental and operational T&E.

*NOTE: For additional information on the SELF Program, contact MAJ Hodge at (407) 384-3658 or DSN 970-3658.*

*MAJ TONY F. HODGE is Project Director for the M2A3 Bradley SELF Program. He is assigned to the U.S. Army Simulation, Training and Instrumentation Command, Orlando, FL. He has a B.S. degree from Alcorn State University and an M.S. degree in administration from Central Michigan University.*



# ARL, UNIVERSITY OF DELAWARE COLLABORATE ON NEW COMPOSITE ARMOR PROCESS

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By Diane S. Kukich

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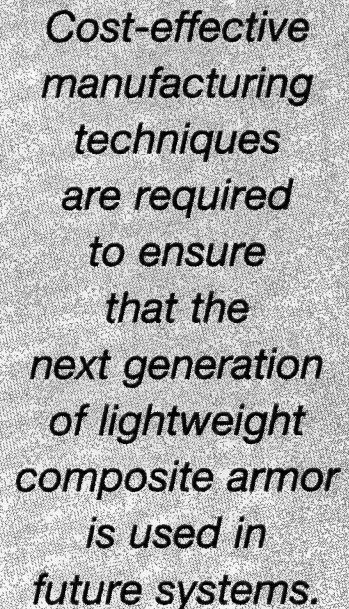
Cost-effective manufacturing techniques are required to ensure that the next generation of lightweight composite armor is used in future systems. Several fabrication techniques, including hand layup and automated fiber placement, have been used to produce composite structures, but affordability and durability have remained major issues. Now, a process developed jointly by the University of Delaware Center for Composite Materials (UD-CCM) and the Army Research Laboratory (ARL) offers reduced costs and increased durability by eliminating the need for multiple processing steps and subsequent joining of the various layers making up the armor "recipe."

With Co-Injection Resin Transfer Molding (CIRTM), multiple resin systems can be injected using a single fiber-layup and mold/vacuum bag procedure. The process enables integration of not only discrete composite layers but also non-composite materials such as ceramic tiles for ballistic protection and metal screens for electromagnetic interference shielding. This work is being carried out under the Composite Materials Research (CMR) Collaborative Program, which was established through a cooperative research agreement between UD-CCM and ARL in 1996. The CMR Collaborative Program is one of three such programs comprising

the ARL's Materials Research Center of Excellence.

During its first year, the cooperative program at UD produced more than 50 joint ARL/UD publications and 5 joint patent applications for technologies related to composites manufacturing, including 1 covering CIRTM. Since the program was initiated, UD and ARL have become virtual extensions of one another per the Army's "extended laboratory concept."

The initial focus of the multidisciplinary, multiple-project CMR research program is on integral armor, a multifunctional hybrid composite combining layers of ceramic tiles, polymer-matrix composites, and integrated special-purpose materials. According to ARL Senior Scientist Dr. Gary L. Hagnauer, "The Army will need lighter weight, higher strength and stiffness, and more robust materials and structures to meet Army After Next requirements for speed, tactical mobility, operational efficiency, logistics, and increased range and lethality of weapon systems." Hagnauer directs the three university programs that make up the Materials Center of Excellence. He added, "Materials cannot just be taken off the shelf to meet future defense demands." Enabling technologies for so-called "materials by design" include composite materials (lightweight, high-strength, multifunctional materials),



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## SUMMARY OF ADVANTAGES OF CIRTM

### Cost savings through

- Reduction of cycle times per part, allowing for higher volume production
- Reduction of manpower costs
- Reduction of the number of processing steps
- Reduction of the energy needed to run the machinery
- Elimination of the need for adhesives (and therefore the need for surface preparation, set-up and tolerance problems, and defects associated with secondary bonding)

### Environmental advantages through

- Reduction of emissions, due to the decreased number of steps and the closed nature of the process
- Reduction of waste in general via more efficient use of material and decreased number of steps
- Elimination of the need for adhesives

### Performance advantages through

- Reduction of weight
- Improvement of bonding through co-cure and therefore improvement of mechanical properties
- Provision of structural contribution from previously nonstructural layers
- Value-added multifunctional enhancements such as fire protection, wear resistance, and moisture-resistant structures
- Built-in repairability of complex multifunctional structures

lightweight integrated armor, and cost-effective manufacturing (intelligent processing, joining).

CIRTM may be one of these enabling technologies. Although Vacuum-Assisted Resin Transfer Molding has proven to be very cost effective in the manufacture of large composite parts, it has been used primarily with single-resin systems. UD Professor John W. Gillespie stated, "By using a single-step co-cure process that injects multiple resin systems, co-injection offers the potential to satisfy multifunctional requirements—for example, structural, fire protection, and ballistic resistance—while reducing costs and increasing quality, performance, and durability. The process also eliminates the need for secondary bonding operations. Our patented Diffusion-Enhanced Adhesion [DEA] process was critical to the development of co-injection manufacturing."

In co-injection, a compatible barrier

layer such as a thin thermoplastic film initially maintains resin separation during infusion. During cure of thermosetting resins, diffusion and reaction of the compatible thermoplastic, which is the basis of DEA, results in a strong, durable interphase between dissimilar materials. DEA bonds have been shown to be superior to conventional adhesive bonds in applications involving ballistic impact.

SIMPROCESS®, a cost model developed at UD by Professor Scott K. Jones, indicates that co-injection yields significant savings over alternative processes such as sequential injection and automated fiber placement. The cost savings result from a variety of factors, including reduced cycle times, manpower costs, processing steps, and energy requirements. Elimination of the need for adhesives also helps bring costs down.

In addition, the single-step co-injection process offers the opportunity to significantly decrease pollution and manufactur-

ing costs. Dr. Bruce K. Fink, an ARL scientist in residence at CCM, pointed out, "The potential to eliminate adhesive bonding is attractive from the viewpoint of not only reducing emissions at the time of initial manufacture but also mitigating the need for future repair due to bond failures." Because of these environmentally friendly aspects of co-injection, the process is one of several technologies that will be investigated under a recent award from the federal Strategic Environmental Research and Development Program to ARL, with UD-CCM and industry participation.

Another advantage of co-injection is that it enables the use of through-thickness stitching to enhance multihit ballistic performance and improve the damage tolerance of integral armor. The effect is similar to that of quilting a multilayered blanket to prevent ripping, tearing, or separation of layers. In the case of armor, stitching prevents delamination and limits damage during ballistic impact. Stitching also has the potential to increase residual strength—that is strength after impact. After the Composite Armored Vehicle (CAV) Advanced Technology Demonstration was completed, the CAV was shipped to the Pentagon for display by United Defense Limited Partnership (UDLP), the contractor for the CAV and the Army's new self-propelled howitzer, Crusader. A highlight was UDLP's demonstration of the damage tolerance and ease of repair associated with this technology.

"We've come a long way in developing this innovative approach, transferring the technology, and addressing scale-up issues," says UD's Gillespie. "But in some ways, our initial work on this process has raised more questions than it has answered. We're still exploring a number of issues, including evaluating various separation methods, optimizing processing conditions and stitching parameters, and establishing the fundamental science base for in-situ formation of the interphase between dissimilar materials during processing. But we're confident that through continued investigation with our government and industrial partners—especially ARL and UDLP—we'll be able to successfully resolve these issues over time. We're very appreciative of the opportunity to work so closely with them through the CMR Program."

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*DIANE S. KUKICH is an editor at the University of Delaware Center for Composite Materials. She gratefully acknowledges the assistance of Professor John W. Gillespie Jr. (UD-CCM) and Dr. Bruce K. Fink (ARL) in preparing this article.*

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# PACIFIC CONTINGENCY CONTRACTING OFFICERS WORKING GROUP

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By MAJ Jon Campbell

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## Introduction

Check out this possible scenario: While scanning your daily e-mail, this message is in your inbox: *I think we need a KO to accompany a CAT deploying to Comoros next month to rebuild a school in support of the CG's ERP—signed CofS.* After looking at an atlas to find Comoros and checking the meaning of the acronyms, you wonder what to do next.

In plain text, the above message is: *I think we need a contracting officer to accompany a civic action team deploying to Comoros next month to rebuild a school in support of the commanding general's expanded relations program—signed Chief of Staff.* In the United States Army, Pacific (USARPAC), if you did not have a contracting officer capable of deploying, you would contact the Office of the Assistant Chief of Staff for Acquisition Management (ACSAM). From there, if USARPAC did not have the internal assets to cover the mission, the Office of the ACSAM would activate United States Pacific Command's (USPACOM) Supply and Services Branch (J424), which loosely controls the Pacific Contingency Contracting Officers Working Group (PCCOWG).

The PCCOWG is the USPACOM/commander-in-chief's (CINC's) Logistic Procurement Support Board (CLPSB)/J424 working group, which recommends standardized policies and procedures for contingency contracting during regional contingencies, joint theater exercises, or natural disaster relief in the USPACOM area of responsibility (AOR), and ensures all contingency contracting requirements

are met.

The PCCOWG is a USPACOM-unique initiative borne of a necessity to have some control over contracting in an AOR that encompasses 43 countries across 13 time zones. In this article, I explain the membership and organization of the PCCOWG, its relationship with the CLPSB, and the spirit of cooperation in a joint environment.

## What is PCCOWG?

The PCCOWG reports to the CLPSB and has formalized procedures with several documents. While *Joint Publication 4.0* covers the establishment of the CLPSB, USCINCPAC Instruction 4230.1C specifically establishes and charges the PCCOWG with supporting the CLPSB. The PCCOWG has a formal charter approved by USPACOM that is reviewed annually and updated as necessitated by the changing environment. Biannual meetings ensure that all contracting commitments in the PACOM AOR are known and met. These meetings also allow the members to become familiar with their counterparts in the sister Services.

## Membership

The PCCOWG is made up of both voting and nonvoting members. The USPACOM component commands and other unified commands within the USPACOM AOR appoint one voting member and other organizations and activities appoint nonvoting members as required. Based on their experience and position, members normally represent the contingency contracting working level and include senior

*During a major joint theater exercise, such as Cobra Gold in Thailand, it is not uncommon for every Service to have representation in the exercise contracting office.*

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enlisted personnel, captains and majors, and GS-12 or 13 civilians. The difference between the voting and nonvoting members is minimal. Voting members represent their respective Services, vote on changes to the charter, and may accept requirements on behalf of their Services. Nonvoting members represent subordinate units, express views on recommended changes to the charter, and provide experience and expertise on specific matters. The chairperson holds the position for 1 year and the position is rotated among the voting members. The chairperson decides when and where to meet, establishes and publishes the agenda, oversees the meetings, and provides the minutes and attendance rosters. Meetings are usually held in Hawaii unless the voting members agree to hold the meeting elsewhere. This has been the case on several occasions when the majority of the members were deployed in support of an exercise or were attending a conference elsewhere. The meeting has been held in Thailand and Korea.

Currently, there are five voting members: USARPAC, Pacific Air Forces, Marine Forces Pacific, Pacific Fleet, and U.S. Forces Korea. Some of the current nonvoting members are U.S. Special Operations Command Pacific, U.S. Army Japan, 25th Infantry Division (Light), Naval Regional Contracting Command—Singapore, Corps of Engineers Pacific Ocean Division, and Defense Contract Management Area Office—Hawaii.

The PCCOWG supports the CLPSB in carrying out three critical acquisition functions for the CINC:

- Promotes cooperation among the services;
- Recommends acquisition policy and procedures to the CLPSB to carry out the CINC's strategic objectives; and
- Assists in the standardization of all acquisition functions and the enforcement of priorities for limited resources.

### Cooperation

During the PCCOWG meetings, each component presents its projected requirements and balances them with any joint requirements. The PCCOWG recommends to the J424 of USPACOM any required taskings to support these requirements if the voting members cannot agree informally who will cover what requirements. Traditionally, each Service covers its own requirements unless it is a joint exercise or the Service does not have the assets to do so. This does not prevent "unprojected" requirements from becoming critical. Due to the unique working relationship among the Services, a phone call between commands usually ensures the mission is supported contractually.

USCINCPAC Instruction 4230.1C addresses the expectations of USPACOM for contingency contracting throughout the USPACOM AOR. The vastness of the AOR makes cooperation vital among the Services and agencies. The CLPSB serves as the functional head for this cooperation, while the PCCOWG serves as the catalyst for making it work. Every effort is made to include all the Services in any PCCOWG activity. Recent activities include DOD's Standard Procurement System (SPS) Contingency Contracting Officer (CCO) training and a Contingency Contracting Conference in Korea.

Cooperation among the Services is excellent, notwithstanding some inevitable interservice rivalry. On numerous occasions, a CCO from one Service has assisted and covered a requirement for another. Examples include an Air Force CCO assisting an Army engineer unit building a road in Cambodia or an Army CCO contracting for a Navy special operations unit in Thailand. During a major joint theater exercise, such as Cobra Gold in Thailand, it is not uncommon for every Service to have representation in the exercise contracting office. One Service is designated

as the "lead" for contracting and is required to provide a Level II-qualified CCO to serve as the chief of the contracting office. The other Services provide CCOs to support the mission.

A PCCOWG goal is to have CCOs capable of working with all of the Services. Both the CLPSB and the PCCOWG agree that the portability of warrants for CCOs from within the USPACOM AOR is accepted among the Services. All warranted contracting officers from any of the other Services are accepted and may contract on any exercise, regardless of the lead agency, without any additional justification or paperwork. Currently, the CCOs employ an automated contracting system adopted by the PCCOWG, a product using a Symantec software called Q & A. This standardization allows every CCO to serve in an office without having to learn a new system. Once an SPS is fielded and all Services have the system, the PCCOWG will transition to the new system. Any CCO may use whatever system they are comfortable with when deployed as an individual to support a requirement. It is only when working in a joint office that Q & A is mandated by the PCCOWG.

The chairperson of the PCCOWG also appoints a custodian to maintain a master library. The library serves as a central repository for all regulatory documents and other information critical to contingency contracting within the AOR. The goal is to develop a central electronic database of sources by country, and lessons learned from previous exercises and deployments. The PCCOWG is in the infancy stage of having the information available on the World Wide Web. This should be available by the end of summer 1998.

### Conclusion

In the ever-increasing world of joint operations, it is a positive reinforcement to have the foundation for joint cooperation in place within the Pacific. The Services, through the PCCOWG, get the job done. The PCCOWG fills the void for the lack of a formal written joint contingency contracting doctrine and ensures customers receive the most efficient and effective support possible.

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# ATC HELPS MARYLAND STATE POLICE CRACK DOWN ON AGGRESSIVE DRIVERS

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By Lena Goodman

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Aggressive drivers, beware!

The U.S. Army Aberdeen Test Center (ATC), Aberdeen Proving Ground, MD, has been working with the Federal Highway Administration and Maryland State Police since August 1996 to develop a prototype aggressive driver imaging system to identify aggressive drivers who threaten the lives of individuals traveling on the Capital Beltway in the Washington, DC, area.

CPT Greg Shipley, Commander of the Maryland State Police Public Affairs Unit, said a number of traffic accidents caused by aggressive driving have occurred in the state and around the country during the past 2 years. "The issue of aggressive driving has now caught the attention of traffic, police and government officials at the local, state, and federal levels. A recent AAA survey showed that the number one concern of motorists was not the drunk driver, but the aggressive driver," he said.

According to Maryland State Police Superintendent COL David B. Mitchell, aggressive driving includes following too closely, changing lanes unsafely, failing to yield right-of-way, speeding, and negligent or reckless driving. "The time has come for the Maryland State Police to lead the way in new traffic safety and enforcement initiatives," he said.

The technology transfer initiative began in August 1996 with representatives from ATC, the Federal Highway Administration, the Maryland State Highway Administration, and the Maryland State Police. It is called "Project ADVANCE"—Aggressive Driving Video and Non-Contact Enforcement.

A key part of the initiative is a prototype developed by ATC engineers—the Aggressive

Driver Imaging System (ADIS). Mike Zwiebel, ATC's Instrumentation Development Leader, stated, "The ADIS is a computer-controlled system that employs two laser devices for detecting speed and distance, and three video cameras for imaging. These devices are all mounted inside a Maryland State Police vehicle.

"ADIS detects a traffic violator, records a digital image and video clip of the approaching vehicle, records several side-view images as the vehicle passes, and records several rearview images after the vehicle passes," Zwiebel noted.

"The side-view images are used to determine a commercial truck's Department of Transportation Motor Carrier numbers. The rearview images are used to determine a car or truck license tag number," Zwiebel added.

ADIS stores the video clip, digital images and vehicle speed in a computer. Shipley said when an ADIS operator is done monitoring, the trooper reviews the acquired images and uses existing database systems to identify vehicle registration or motor carrier identification of violators.

"The vehicle owner will receive a letter of warning and a set of photographs showing the violating vehicle and listing of traffic violations," Shipley said. "Citations will not be issued by mail since Maryland police don't have statutory authority to do this except at certain traffic intersections with red lights," he continued, noting that the only time citations would be issued is when ADIS is operated in coordination with a nearby stopping team.

According to Shipley, "The ADIS operator would notify the stopping team of the approaching violator. A member of the stop-

ping team would stop the violator and issue the citation, based on the testimony of the ADIS operator who witnessed the violation and saw the stopping team member stop the correct vehicle."

Zwiebel said advantages of the system include improved mobility, single-trooper operation, reduced risk to troopers by eliminating the need for stopping teams on dangerous interstates like the Capital Beltway, reduced traffic congestion by eliminating roadside traffic stops, and the ability to provide video and still photo records of the violation.

"The Maryland State Police will be conducting a formal study over the next year to evaluate the effectiveness of this technology as a tool in reducing the occurrence of aggressive driving on the Capital Beltway," Zwiebel added.

Maryland State Police officials emphasized that aggressive driving kills, and noted that Maryland roads will be safer thanks to this advanced law enforcement technology provided with the help of ATC expertise.

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# THE VEHICLE CONTROL UNIT FOR THE HIGH MOBILITY MULTIPURPOSE WHEELED VEHICLE

## Introduction

Since its fielding in the 1980s, the High Mobility Multipurpose Wheeled Vehicle (HMMWV) has experienced high failure rates of its protective control box (PCB), significantly impacting its readiness and operations and sustainment costs. Located under the driver's dashboard, the PCB houses the HMMWV's starter, glow plugs and accessory relays, and plays an essential role in operations such as starting the vehicle. In early 1997, the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC) took on the challenge of solving the PCB failure problems. This article describes that challenge and the ensuing development of a vehicle control unit (VCU) that will replace the PCB and glow plug controllers (GPCs) currently found in HMMWVs.

## Background

Backed by its long-standing tradition of finding innovative solutions to complex problems, engineers on TARDEC's Rapid Prototyping Team believed they could redesign the PCB not only to improve its functionality, but also its performance. Their task was to develop a solution that would provide the soldier in the field with increased readiness, while simultaneously reduce the time spent on maintaining the HMMWV's electrical control systems.

Paramount to the TARDEC prototyping team effort was that the PCB remain capable of handling unique scenarios associated with, but not limited to starting the vehicle. For instance, the PCB must not only be capable of reliably starting the HMMWV under normal operating temper-

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By John J. Schmitz and  
Michael K. Cadieux

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atures, but it must also maintain the same reliability during cold weather starting. Scenarios such as these, however, have become problematic due to the limited technology at the time the PCB was designed. In the early 1980s, the commercial marketplace simply did not have reliable and cost-effective solid-state electronic technologies to handle HMMWV requirements such as starting in various environments.

## Identifying The Problems

With this in mind, TARDEC's engineers thoroughly researched the problems experienced with the PCB and identified the problematic issues that were causing its failure. The first problem was that the PCB relays housed within the box were burning out much too quickly. Some of these burnouts were attributed to the range of voltages the HMMWV encounters and the voltages at which it must perform (9-34 volts (V)). Some of the relays within the PCB were designed originally to operate at 12V. In many cases, however, 24V were being applied. The second problem was that the PCB contacts housed within the box were welding shut. This failure was due to the high amounts of current being sent through the contacts.

The most critical problem the HMMWV was experiencing, however, was the rate

at which glow plugs were burning out. Glow plugs are needed by the HMMWV's diesel engine to raise the temperature of the fuel and air mixture when the engine is not hot enough to create combustion. Typically, this problem occurs when the HMMWV operator repeatedly turns the ignition on and off in an effort to start the vehicle. This can lead to what is commonly referred to as stacking. Stacking is a term to describe the glow plugs when they become too hot (above 2,000 F), which can occur when they are at full power for more than 10 seconds at a time. Since the PCB design is constrained by now obsolete electronic technology, the unit does not possess the capability to detect a stacking condition. As a result, the glow plugs tend to burn out. The glow plug temperature is primarily dependent on the battery voltage and the amount of time voltage is applied to the plug, and less dependent on the temperature of the engine block.

## Solving The Problem

TARDEC's goal was to develop an innovative and cost-effective replacement system that would not only be capable of handling every function the PCB performs, but also handle problems such as cold temperature starting and stacking. To achieve this, TARDEC's engineers looked at the problem "outside the box," and leveraged today's state-of-the-art electronic technologies that are readily available in the commercial marketplace. Thus, they were able to develop a unique solution to a very complex problem.

Advances in solid-state electronics technologies during the last 10 to 15 years enabled TARDEC's engineers to com-

pletely reengineer the PCB, improving both its reliability and performance. The TARDEC redesign led to development of the VCU, a completely solid-state device that consists of transistors, diodes, and other electronic parts.

An 8-bit microcontroller is the "heart and brains" of the VCU. It is a highly integrated chip, which includes a central processing unit, random access memory, erasable programmable read only memory, timers, and an interrupt controller. It also has several analog-to-digital converters to read battery voltage and temperature. Since this microcontroller provides a "one-chip solution," TARDEC's engineers were able to drastically reduce the number of parts and design costs by incorporating the microcontroller into the VCU.

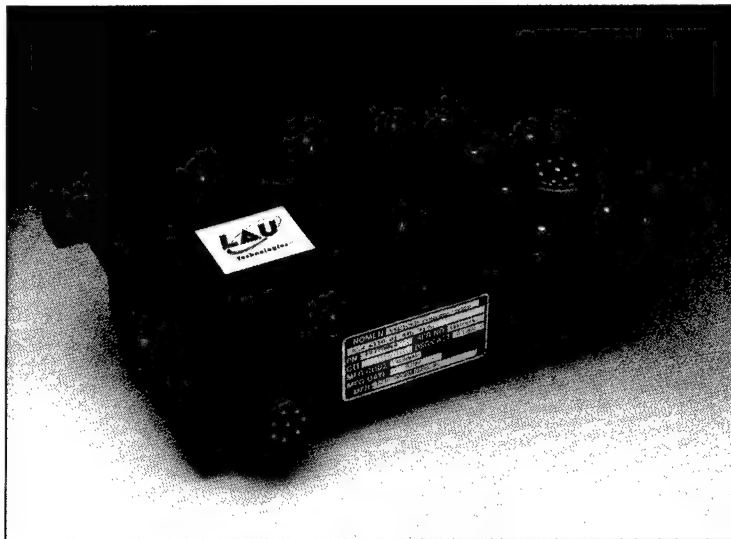
The microcontroller's software is programmed to collect, monitor and evaluate data coming from various parts of the HMMWV's electrical system, such as the battery. This process ultimately enables the VCU to provide power to the glow plugs. Traditionally, energy was sent to the glow plugs using a much cruder means: the engine temperature was used as a gauge without considering the condition of the battery. The VCU only monitors the condition of the battery to control how much energy is sent to the glow plugs.

### Other Innovations

Several other innovative approaches have been incorporated to enhance the HMMWV's electrical system operation. Currently, the PCB is connected via a wire harness to another electronic device, the GPC. Previously, when something went wrong with the HMMWV's glow plugs, the mechanic usually replaced the GPC when he or she replaced the faulty glow plugs. To help reduce maintenance costs and streamline the vehicle's electronic components, TARDEC's engineers incorporated the functions of the GPC into the VCU, and eliminated the need for the GPC.

In addition, all PCB relays have been eliminated in the new design. Formerly, a single PCB relay was used to connect all eight glow plugs, and when the vehicle was turned on, all eight glow plugs were turned on. The VCU now separates the glow plugs into eight individual channels, reducing switching noise and improving HMMWV performance. The VCU is also equipped with individual transistors for each glow plug, enabling the HMMWV to start its engine even when several glow plugs are burnt out. This was previously impossible using the PCB configuration.

In addition to the technological and operational benefits previously described, the VCU offers a number of other enhancements. For example, a thick white smoke that occurred during initial startup with the PCB is significantly reduced or eliminated. This smoke



Protective control box.

was caused by improper heating of the glow plugs.

TARDEC's engineers have also addressed the question "How much work is needed to replace the unit on the vehicle?" The switch from electromechanical to solid-state technology sharply decreased both the size and weight of the unit. However, a decision was made to keep the dimensions and mounting of the PCB the same for the new unit. Thus, the only thing the soldier needs to do to replace the unit with relative ease is to drill one additional hole into the mounting area.

### Testing

During development of the initial prototype, a 4-month in-vehicle field test of the VCU was conducted from February 1997 to June 1997. This timeframe ensured that a HMMWV equipped with the new VCU would be exposed to temperatures as low as 9 F or as high as 85 F. During the 4-month test, an attempt was made to start the HMMWV every business day. The HMMWV started every time. The HMMWV also started in a cold chamber with a temperature of minus 25 F.

Additional testing procedures involving 25,000 start sequences have also been developed and are currently under way. To ensure that the VCU is reliable under all circumstances and scenarios, the number of start sequences was increased two and a half times over what the PCB went through to ensure that the new design meets rigorous demands.

### Conclusion

Preliminary data indicate that this innovative solution not only solves the failures that have plagued the HMMWV in the field, but offers a host of technological, operational and environmental improvements as well. This was achieved by focusing on the basic performance requirements of the PCB, while applying today's state-of-the-art commercial solid-

state electronics technologies. TARDEC engineers believe this approach can readily be applied to other tactical wheeled vehicles in the fleet that are experiencing the same types of problems.

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# ARMY LOGISTICS GOES ONLINE

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By James A. Smith

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Beginning in the late 1980s, the Army dragged me into the electronic universe, commonly referred to today as the Internet. I passively resisted because it was and at times still is, a nuisance to me—all those keyboard codes, those hard to remember URL addresses, all that superfluous information, all that “surfing the net.” When I thought I was close to what I wanted, I would spend my valuable time searching page by page and then I missed it. By this time, I was so distracted that I forgot what it was I had been looking for. I just couldn’t get my arms around it. For me, the electronic age consisted of typewriters and adding machines. My talents were meant to be used with a yellow No. 2 stubby pencil. As I went to work each day, I kept telling myself, “change is good ... change is good!!”

My job has gotten easier and, yes, sometimes faster because of the personal computer. It also means I receive a lot more work because now I have more time on my hands. Charts, graphs and reports that used to take days or weeks to complete I can now do in a matter of hours. I don’t have to send my work to a secretary or graphics department to find out that what I wrote is not quite what I meant to say, or that the layout is wrong. I can now make mistakes that only I know about. Ain’t computers great?

Now a small group is attempting to make the logistician’s life a little easier. Almost every command or activity has a home page or something on the World Wide Web. The problem is finding it. The Department of Army Integrated Logistics Support Executive Committee, under the sponsorship of the Army’s Office of the Deputy Chief of Staff for Logistics, perceived that locating logistics information on the World Wide Web was a problem. They suggested the formation of a team to look into the problem. That team of representatives from various commands and activities determined the direction to take and the purpose of the needed website, and began the design and implementation of an Army logistics website.

The idea is to allow the logistician to “put his or her arms around it.” They should be able to go to a single website, determine what they want, and then go directly to it, with minimal time and effort. “Surfing” would not be required, nor the need to remember numerous electronic addresses. The numerous URLs would be converted to

noun names all on a single convenient website through the modern day miracle of electronic “linking.” The strength of this concept is the individual’s ability to easily access current information and data from a wide variety of Army sources.

The U.S. Army Logistics website is now online at [www.logistics.army.mil](http://www.logistics.army.mil). This website is a virtual melting pot of logistics information. It provides online, easy access to key information and documents that will allow the logistician early insight into government acquisitions, procedures, and events. The intent is to provide as much logistics information as possible at one site. By linking to existing websites within the Army and other Services, this site will allow the logistician greater effectiveness and efficiency.

The site has two areas from which to seek assistance—a Navigational Guide and the always-reliable “FAQ” (Frequently Asked Questions). The guide and FAQ have been placed upfront to better assist the user. Each topic on the home page is identified and explains the information you will be able to find. The main areas are acquisition, fielding, and sustainment. Under these three broad areas are related topics intended to aid the logistician before, during, and after the system is fielded. These areas contain links to the *Commerce Business Daily*, acquisition reform, regulations, total package fielding, contractor logistic support, software logistics, and numerous other topics. The FAQ answers questions commonly asked by people like me who get lost every time we go more than 10 miles from home. We know we’re lost, but we rarely request assistance.

At the top of the page is a rotating button with the word “new.” A click on this will show you all of the latest innovations for logistics. This section will be kept updated.

Not everything deals directly with projects or weapon systems, so we’ve added a few more buttons for you to practice “clicking.” Each command can submit information on its initiatives and products. When you have a meeting related to logistics and want to get the word out, enter the information in the Logistics Calendar. Training opportunities are also listed. The Library contains all

of the electronic data, such as military standards, technical manuals, and DOD documents that we’ve been able to find. If you want to link directly to a logistics home page, you can do that under “Commands.” Also under Commands are maps showing the location of depots, training and test ranges; the force structure; and other locations. Clicking on “Future” will provide you with information on the official direction that the Army is headed, including Force XXI, Vision 2010, and the Army After Next. There is more, such as Points of Contact and Acronyms, but you can easily peruse these on your own.

The site is linked to the Office of the Assistant Secretary of the Army for Research, Development and Acquisition (OASARDA) home page to provide a chat room. The room is not yet available, but when it is, you will be able to set up the time and coordinate with OASARDA for availability. This will allow live, online meetings.

The site is intended to allow for a lean, agile, and responsive source of timely information for the Army logistician. While you will find a lot of logistics information at this site, there still remains a lot that has not been placed on the web by the commands or activities permitting it to be captured. Eventually this will change, and as it does, so will this website.

If you have information, or a source useful for logisticians and functional specialists, send the URL address to [scott\\_becker@stricom.army.mil](mailto:scott_becker@stricom.army.mil), so others can use it as well. I’ve found over the years that it’s a good thing to leverage someone else’s ideas and efforts, and doing so can lead to cost avoidance! So bookmark this site and return often. It will be constantly changing as fast as the information available to the website changes.

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*JAMES A. SMITH, now retired, was a senior retired integrated logistics system manager with the U.S. Army Simulation, Training and Instrumentation Command, Orlando, FL, when he wrote this article. The U.S. Army Logistics website was developed under his leadership.*

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## ARMY RD&A WRITER'S GUIDELINES

### About Army RD&A

Army RD&A is a bimonthly professional development magazine published by the Office of the Assistant Secretary of the Army (Research, Development and Acquisition). The address for the Editorial Office is: DEPARTMENT OF THE ARMY, ARMY RDA, 9900 BELVOIR RD SUITE 101, FT BELVOIR VA 22060-5567. Phone numbers and e-mail addresses for the editorial staff are as follows:

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### Purpose

To instruct members of the RD&A community relative to RD&A processes, procedures, techniques and management philosophy and to disseminate other information pertinent to the professional development of the RD&A community.

### Subject Matter

Subjects of articles may include, but are not restricted to, policy guidance, program accomplishments, state-of-the-art technology/systems developments, career development information, and management philosophy/techniques. Acronyms should be kept to a minimum and, when used, be defined on first reference. Articles with footnotes are not accepted.

### Length of Articles

Articles should be approximately 1,500 to 1,600 words in length. This equates to approximately 8 double-spaced typed pages, using a 20-line page.

### Photos and Illustrations

Include any photographs or illustrations which complement the article. Black and white is preferred, but color is acceptable. Graphics may be submitted in paper format, or on a 3 1/2-inch disk in powerpoint, but **must be black and white only, with no shading, screens or tints**. We cannot promise to use all photos or illustrations, and they are normally not returned unless requested.

### Biographical Sketch

Include a short biographical sketch of the author/s. This should include the author's educational background and current position.

### Clearance

All articles must be cleared by the author's security/OPSEC office and public affairs office prior to submission. The cover letter accompanying the article must state that these clearances have been obtained and that the article has command approval for open publication.

*Offices and individuals submitting articles that report Army cost savings must be prepared to quickly provide detailed documentation upon request that (1) verifies the cost savings; and (2) shows where the savings were reinvested. Organizations should be prepared to defend these monies in the event higher headquarters have a higher priority use for these savings. All Army RD&A articles are cleared through SARD-ZAC. SARD-ZAC will clear all articles reporting cost savings through SARD-RI. Questions regarding this guideline can be directed to SARD-ZAC, Acquisition Career Management Office, (703)695-6533, DSN 255-6533.*

### Submission Dates

Issue	Author's Deadline
January-February	15 October
March-April	15 December
May-June	15 February
July-August	15 April
September-October	15 June
November-December	15 August

Authors should include their address and office phone number (DSN and commercial) with all submissions, as well as a typed, self-adhesive label containing their correct mailing address. In addition to providing a printed copy, authors should submit articles on a 3 1/2-inch disk in MS Word, or ASCII format. Articles may also be sent via e-mail to: bleicheh@aaesa.belvoir.army.mil



## From The Acting Director, Acquisition Career Management Office (ACMO)

Our 1998 Army Acquisition Corps (AAC) Roadshow effort is well under way, with visits to Huntsville, AL, in March and Orlando, FL, in April. Visits to Fort Monmouth, NJ, and Picatinny Arsenal are scheduled for June. We hope that you take advantage of the opportunity to hear the roadshow briefing, "Converting the Army Acquisition Corps Vision into Reality," presented by Keith Charles, Deputy Director for Acquisition Career Management, and to consult with our Mobile Acquisition Career Management Office team onsite at the roadshows. The roadshow schedule is available on the AAC home page at: <http://dacm.sarda.army.mil>. Be sure to check the schedule for a roadshow in your area!

We have received very positive feedback from the attendees of the leadership training seminars being offered to Corps Eligibles (CEs) in conjunction with the roadshow. All CEs will be contacted by the Acquisition Career Management Office (ACMO) to arrange attendance at these seminars.

We welcomed the YG98 Competitive Development Group at an orientation in April, and I congratulate all of the selectees. Shown in the article below is a list of the selectees and some information about their April orientation. Congratulations also to the 27 students who graduated in March from the Materiel Acquisition Management Course.

We are actively pursuing AAC success stories. LTG Paul Kern, Director of the AAC, is also pursuing stories to publicize the benefits of the AAC to soldiers and civilian employees of the Department of Army. To assist the ACMO in this effort, please notify us of acquisition successes in your regions. We will publicize the stories through all available means. Not only will your efforts be appreciated, but they will also serve to educate other acquisition professionals and the rest of the Army.

A *Federal Register* notice announcing the DOD Civilian Acquisition Workforce Personnel Demonstration Project was published March 24, 1998. The ACMO will manage and provide oversight for the Army's implementation of the project. The next issue of *Army RD&A* will include an article on this topic.

Watch for the *Army Acquisition Workforce Newsletter*, which will contain articles by members of the Acquisition Workforce. This newsletter will be distributed to the entire Acquisition Workforce every other month, alternating with *Army RD&A* magazine. Finally, the integrated *Civilian/Military Playbook* will be available in June! The playbook is an excellent resource for

the Army Acquisition Workforce, and provides a framework for managing your acquisition career.

**Mary Thomas**  
Acting Director  
Acquisition Career  
Management Office

## YG98 Competitive Development Group

On Jan. 23, 1998, the U.S. Total Army Personnel Command (PERSCOM) announced the second iteration of the Army Acquisition Corps' Competitive Development Group (CDG). The 25 primary board selectees for CDG YG98 and their current commands are as follows:

Jerry L. Cook	Test and Evaluation Command
Jean A. Grotophorst	Aviation and Missile Command
Amelia B. Hatchett	PEO-AMD
Maria L. Holmes	Aviation and Missile Command
Sharon M. Johnson	Simulation, Training and Instrumentation Command
Linda S. Johnston	Communications-Electronics Command
Samuel M. Jones	Simulation, Training and Instrumentation Command
Emerson L. Keslar	Aviation and Missile Command
Carlos B. Kingston	Aviation and Missile Command
Sam D. Lail Jr.	Aviation and Missile Command
Raymond J. Lazzaro	Test and Evaluation Command
Kevin A. Maisel	PEO-STAMIS
Rinnetta D. McGhee	Communications-Electronics Command
Mario J. Musotto	Tank-automotive and Armaments Command
Douglas W. Packard	Military Traffic Management Command
Raymond J. Pietruszka	Aviation and Missile Command
Deborah Pinkston	PEO-Tac Msl
Patricia E. Plotkowski	Tank-automotive and Armaments Command
Anita D. Randall	Special Operations Command
Mark E. Reavis	PEO-Tac Msl
Clifton O. Reynolds	PEO-C3S
Dominic Satili	PEO-C3S
Steven J. Stegman	Aviation and Missile Command
Richard H. Thorn	Space Missile Defense Command
Larry W. Wakefield	Simulation, Training and Instrumentation Command

Two of the primary selectees declined the program because of more suitable opportunities within their current commands. As a result, the first two alternates were offered the program and accepted. The two alternates are Sharon D. Lee, Aviation and Missile Command, and Gloria L. Morales, Military Traffic Management Command.

The orientation for CDG YG98 was held April 27-29, 1998, in the Washington, DC, area and was hosted by Keith Charles, Deputy Director, Acquisition Career Management (DDACM). LTG Paul Kern (Director of the

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Army Acquisition Corps and Director for Acquisition Career Management) and Donna Tyson (business motivational speaker) were keynote speakers.

The CDG YG98 selectees and their supervisors and sponsors finalized the selectees' 3-year Individual Development Plans, which will guide the selectees through 3 years of training, developmental activities, and education. YG98 selectees also participated in workshops that provided them with the tools to better prepare them for their career development and new assignments. At the orientation dinner banquet, Kern and Charles presented the selectees with certificates and pins honoring their selection to the program. In addition, YG97 members welcomed the new selectees and shared their experiences with them. CDG YG98 will report to their developmental assignments in July 1998.

## The Defense Leadership And Management Program

The Defense Leadership and Management Program (DLAMP) is a new Department of Defense (DOD) competitive leader development program. It was developed by the Office of the Secretary of Defense (OSD) in response to recommendations by the Commission on Roles and Missions, which called for changes in the way senior civilians are trained, educated and professionally developed. The objective of DLAMP is to prepare, certify and continuously educate and challenge a highly capable, diverse, mobile cadre of senior DOD civilians.

### Benefits

DLAMP is a systematic program for civilian leader development, affording significant benefits to participants and their sponsoring organizations. Each participant will be given the opportunity to complete a comprehensive development program including:

- A 3- or 10-month program of professional military education, with emphasis on national security decisionmaking. The new 3-month curriculum is being developed by the National Defense University. Additional quotas in the five existing Senior Service Colleges are provided for the 10-month program.
- A minimum of 10 graduate-level courses in national security, leadership and management issues, to develop familiarity with the range of subjects and issues facing Defense leaders. Each course is taught for 2 weeks at a new Defense facility in Southbridge, MA.
- A rotational assignment of at least 12

months for career broadening. Assignments will be to a different Defense component, occupational area, or organizational level.

- *Component and occupation-specific developmental courses.* For the Army, this includes the civilian leader development core curriculum and applicable Army Civilian Training, Education and Development System (ACTEDS) plans.

Each participant's development will be guided by a structured mentoring process. Participants will meet these requirements on an incremental basis during a period of up to 6 years, generally in a temporary duty status from their home station. Previous education and experience may fulfill some of the DLAMP requirements.

Participation in this program should enhance an individual's competitive standing for filling key leadership jobs throughout the DOD. A substantial number of leadership positions (GS-14, 15, and SES) in OSD and the components will be designated as DLAMP key positions. DLAMP participants and graduates will be given priority consideration in filling these jobs when they become vacant. (Policy and procedures on priority consideration are currently under development.)

### First DLAMP Class

The first DLAMP class was selected in December 1997. Forty-five Army employees (GS-14/15) were selected along with 232 employees from other Defense components. Of the 45 Army employees, 17 were Army Acquisition Corps members. The current plan is for the program to be announced annually in the spring and to extend the announcement to GS-13 personnel.

### Expenses

All participant expenses (to include tuition, temporary duty travel and transportation) are centrally funded by the DLAMP. Additionally, when participants are assigned to long-term training, the DLAMP office will provide temporary backfill salary at a rate of 50 percent of the cost for participants on rotational assignment or attending an in-resident, 10-month professional military education program.

### How To Apply

Applications, other forms and additional information are contained in the FY98 Catalog of *Army Civilian Training, Education and Professional Development Opportunities*. This catalog is accessible via the Internet on the Army's Civilian Personnel Online home page at <http://cpol.army.mil>. Interested employees should contact their servicing civilian personnel office or civilian

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personnel advisory center for local procedures and deadlines.

### Additional Information

For additional DLAMP information, including answers to the most frequently asked questions, check the PERMISS article also in Civilian Personnel Online. Log on to <http://cpol.army.mil>, click on "PERMISS," and search on "DLAMP."

### AAC Central Management

MG Thomas W. Garrett, Commanding General, U.S. Total Army Personnel Command (PERSCOM), approved the merger of PERSCOM's Civilian Acquisition Management Branch and its Military Acquisition Management Branch into **one** Acquisition Management Branch (AMB). The AMB is staffed with military assignment officers, military personnel management specialists, military personnel technicians, civilian functional acquisition specialists and personnel staffing specialists. They will jointly administer the Army Acquisition Corps (AAC) Central Management Program at PERSCOM. This merger ful-

fills the AAC goal to establish a **single** management structure to oversee, direct, and administer the central management of military and civilian AAC members.

### 27 Graduate From MAM Course

Twenty-seven students graduated in March from the Materiel Acquisition Management (MAM) Course, Class 98-002, at the U.S. Army Logistics Management College. The graduates included two foreign officers, one from South Korea and one from the Philippines.

The Distinguished Graduate Award was presented to CPT Edward Swanson, who is assigned to Fort Monroe, VA.

The 7-week MAM Course provides a broad knowledge of the materiel acquisition process. Course areas include acquisition concepts and policies; research, development, test, and evaluation; financial and cost management; integrated logistics support; force modernization; production management; and contract management. Emphasis is on developing midlevel managers who can effectively participate in the management of the acquisition process.

## NEWS BRIEFS

### CECOM and NDIA Sponsor International Trade Show

MG Gerard P. Brohm, Commander of the U.S. Army Communications-Electronics Command (CECOM) and Fort Monmouth, NJ, has approved a co-sponsorship agreement between CECOM and the National Defense Industrial Association (NDIA) to host an International Trade Show in October 1998.

CECOM and NDIA invite U.S. manufacturers of command, control, communications, computers, intelligence, electronic warfare, and sensors (C4IEWS) equipment to demonstrate their products to potential foreign customers at the trade show on October 26 and 27. Providers of related support equipment or services (including, but not limited to, power sources, environmental controls, and perimeter security sys-

tems) are also welcome.

"This will be an ideal opportunity for manufacturers to display or exhibit equipment that has potential for foreign military sales or has a history of foreign military sales," said Eugene P. Bennett, Director of CECOM's Security Assistance Management Directorate, "It also will provide a forum for dialogue between Army C4IEWS managers, U.S. industry, and foreign customers."

For more information or to register, contact Janet Steinberg, Lockheed Martin Corp., 620 Tinton Ave., Building B, Tinton Falls, NJ 07724 (732-389-0390).

## ***The Break-Through Illusion***

By Richard Florida and Martin Kenney  
Harper-Collins Basic Books, 1990

*Reviewed by William C. Pittman, U.S. Army Aviation and Missile Command (Research, Development and Engineering Center).*

This book provides a clearer understanding of the major life cycle management challenge shifting from a front-end focus on acquisition and its cost to a total ownership focus.

The authors are former professors at Ohio State University. They draw on an extensive array of documentary resources and interviews to provide deeper insight into why the American high technology system is defeated in the commercial marketplace and why major weapon acquisition programs go astray. This well-researched book contains 10 chapters and is organized into 3 sections: origins and institutions, limits, and beyond the break-through illusion. The authors begin by explaining how the American follow-through industrial system emerged as a tower of strength when the industrial research laboratory (typified by Thomas Edison's research laboratory) was merged with manufacturing organizations. This merger provided a continuous process of product development and improvement for the marketplace. The ideas that led to the replacement of the follow-through system with the breakthrough illusion were introduced when Ford Motor Co.'s system of assembly line manufacturing was combined with Fredrick Winslow Taylor's concept of scientific management. The process of breaking down jobs into their most fundamental components, the introduction of more powerful machine tools, and the standardization of production processes led to impressive increases in productivity that made America the "arsenal of democracy" in World War II. Unfortunately, the same concepts and processes that led to America's emergence as a world industrial power set in motion behavior that had undesirable social consequences and a negative impact on long-term productivity. This impact did not become fully evident until the early 1970s.

In the post-World War II period, efforts to mold the research and development (R&D) function with the principles of scientific management isolated production engineers and the R&D laboratory from manufacturing operations and led to the growth of corporate bureaucratic systems to man-

age R&D operations.

The high-technology industry in post-World War II formed a symbiotic relationship with new sources of financing in response to the inability of the established industrial base to adapt to change. Venture capitalists learned that one successful start-up firm could offset 10 failures. Thus, in trading ready cash for part ownership, venture capitalists made the investment, assisted with startup, recruited managers, and then after a successful breakthrough, exited with a nice profit. The high payoff in this process compared to yield on corporate stocks and bonds imparted a distinctive bias in the direction of the breakthrough psychology, particularly during the explosive growth of venture capitalism in the 1980s.

The authors argue that patchwork solutions by both the private sector and government are superficial because they do not connect with the deep-seated nature of the underlying cultural problems. The efforts at restructuring, downsizing, and reorganizing the R&D laboratory are viewed with skepticism by the authors. Efforts to capitalize on automation are limited by attempts to fit automation in the mold of older concepts, such as the assembly line, and by management's contempt for production workers. Intervention by different government agencies is uncoordinated and without regard for larger policy issues. Linking large and small firms in consortiums is an enormously difficult challenge that is complicated by intellectual property issues, the litigation explosion, and foreign firms playing the same game.

In chapter 10, Florida and Kenney outline a plan for restoring the follow-through economy that includes making the shop floor a critical area of innovations, reconnecting the factory and the R&D laboratory, and building a network of firms. These actions would be positive moves to strengthen the weapons acquisition process, but difficult to achieve.

General Accounting Office studies show that approximately two-thirds of the critical technologies needed by the Department of Defense have commercial potential, but the other one-third have limited commercial potential. These are technologies critical for national Defense but with no application in the commercial marketplace. A strong civilian economy is an essential foundation to build a strong military, but Defense policy must also provide for Defense needs the civilian economy cannot fill, a topic the authors fail to examine.



## ***The Soldier's Load And The Mobility Of A Nation***

By Colonel S.L.A. Marshall, Published by the Marine Corps Association, Quantico, VA

**Reviewed by Joe Sites, Vice President, Director for Defense Systems, BRTRC Inc., Fairfax, VA.**

The material in this book appeared originally in *The Infantry Journal* and *The Combat Forces Journal*. The book received its copyright in 1950 from the Association of the U.S. Army, was reprinted by the Marine Corps Association in 1980, and is currently a Commandant's Reading List selection. The Commandant's Reading List is a part of the Marine Corps Professional Reading Program, described immediately following this review.

It is a fair question to ask: Why should a review be published on a book that is almost 50 years old? The simple answer is that COL Marshall, later BG Marshall (U.S. Army Reserves), raised issues that are as pertinent today as they were in the 1940s. Although the material is presented in two parts, "The Mobility of the Soldier" and "The Mobility of a Nation," the problems presented are interwoven.

In addressing the soldier's load, Marshall is concerned about the lack of respect for the limitations of the "human animal" (author's term). "The Roman legionary recruited usually at twenty and selected from the peasantry on a basis of sturdy strength rather than height, carried eighty pounds on his body when marching on the smooth Roman roads. Though that seems brutal, we should at least add the footnote that 2000 years after the legion, the American Army dropped men from Higgins boats and onto the rough deep sands of Normandy carrying more than eighty pounds." Marshall contends that the load was far too heavy, contained unnecessary items and contributed directly to the death of many of our soldiers.

One of Marshall's comments has a particular bearing on our current desire to compensate for reduced numbers of forces by providing more effective forces: "I repeat that 5,000 resolute and physically conditioned men will hit twice as hard and therefore travel twice as far when they are sent into battle with a reasonable working load as 15,000 men, the majority of whom have been whipped before crossing the starting line by the weight they were carrying." To support his arguments, the author provides the results of many U.S. and foreign studies.

Relative to the mobility of the nation, the author points out that a greater capacity to deliver goods results in an increase in the quantity and kinds of goods to be delivered. Marshall cautions that the load on the nation must be examined in the same way that we should examine the soldier's load. He summarizes this argument as follows: "Whatever is manufactured beyond what is likely to be needed, whatever is put into the supply pipeline that might have been eliminated at no cost to the army's hitting power, inevitably decreases the volume of fire delivered against the enemy—lessens the chance of victory."

In looking at the "then future," now our present, Marshall predicted the need for the following logistics system: "Highly mobile advanced bases, field bases that scarcely need to resort to dumping, ports that measure their capacity in the speed of turn-around of the carriers in both directions, maintenance crews as adept with a tommy gun as with a grease gun—these things mean the kind of strategic mobility the future requires."

Today, as we introduce new equipment into the Army, it is extremely important to consider Marshall's concerns with the load of the soldier and the load on our nation. After all, 60 pounds of lightweight equipment is a load of 60 pounds. This book should be "must" reading for anyone involved in equipping our soldiers.

## **The Marine Corps Professional Reading Program**

Marine Corps Order 1500 promulgates guidance on the Marine Corps Professional Reading Program. The program consists of three parts: the Commandants Reading List, the Current Issues Reading List, and the Commandant's Choice. The program establishes by grade the number of books that must be read annually. Further information can be obtained from the Marine Corps University home page at: <http://www.mcu.quantico.usmc.mil/mcu/cmcread.htm>.

## ***Field Guide To Project Management***

Edited by David I. Cleland, John Wiley & Sons, 1998

**Reviewed by LTC Kenneth H. Rose (USA, Ret.), a project manager with the Waste Policy Institute in San Antonio, TX, and a former member of the Army Acquisition Corps.**

Project management literature is not an endangered species. The busy project manager may find it difficult to select just the right resource from all the abundant offerings. A new book, *Field Guide to Project Management*, edited by David I. Cleland, makes the choice considerably easier.

A hands-on tool intended more for application in the field than for study in the classroom, the book is at once comprehensive, useful, and complete. It comprises 33 bite-size, stand-alone chapters organized into 5 sections that allow the reader to pick and choose as needed or to survey across general themes.

Cleland's own introductory chapter defines projects as building blocks in the design and execution of organization strategies. He names the key elements of project management—organization matrices, project planning, information systems, project control systems, and cultural ambience—and points to subsequent chapters that present further illumination.

Chapter 2, "The Elements of Project Success," breaks the mold of traditional project management, that is, the triple constraint of cost, schedule, and performance. That paradigm simply doesn't work in the modern business world because its focus is entirely internal. It does not consider the fourth essential element: customer satisfaction. Although customer needs are addressed in a good requirements analysis and are the cornerstone of project initiation, the manager's mantra of "cheaper, faster, better" is no longer adequate. A successful project manager must consider customer concerns throughout the life cycle of the effort.

Section II, "Project Planning Techniques," includes 10 chapters. Those that address on-time performance (Chapter 8), controlling project costs (Chapter 9), and managing risks (Chapter 12) may be of prime interest to military readers. Chapter 11, "Developing Winning Proposals," should not be overlooked. It gives military readers a better understanding of what contractors go through in obtaining work from government organizations. Given the built-in truncation of uniformed careers, perusal of this chapter might also be prudent preparation for the future.

Eleven chapters in Section III address various aspects of project leadership. One of the most informative is Chapter 15, which discusses means of motivating all stakeholders to work together. Again, the importance of customer satisfaction arises as a key measure of project success. This chapter also identifies stakeholders for internal and external projects, and describes how they differ. It prescribes an eight-step public relations/participation plan that will facilitate progress of the project.

Building high-performance project teams, the subject of Chapter 18, may be especially useful in enterprises where the overall organizational structure is hierarchical with unflinching lines of authority. The chapter

describes typical phases of team development and the types of individual behavior and group interaction that may be encountered, and exploited, in each.

Communication skills is the subject of Chapter 20, "How to Get the Right Message Across," which covers the subject from the perspectives of the neophyte, novice, developing, and experienced project manager.

Project oversight is the general subject of the six chapters in Section IV. Chapters 24 and 25, which deal respectively with project management information systems and selecting/using project management software, are complementary and should be considered together. Chapter 26, "Total Customer Satisfaction," provides the how-to follow-on to previous admonitions about the importance of the subject. A case study approach to project evaluation in Chapter 27 provides practical advice and describes both objectives and processes for an evaluation system that has been named "best in class" through several benchmarking experiences.

The last section, "Team Management," includes two chapters of special relevance to military project managers. Chapter 29, written by editor Cleland, describes different types of teams and how they might be applied. Cleland introduces his self-coined term "teamocracy" to describe organizations in which teams are the basic structure for bringing about collaborative effort across functional and organizational boundaries. He describes the benefits of teamocracy and how it differs from traditional approaches.

Concurrent engineering teams are addressed in Chapter 32 along with criteria for an effective team and the details of staffing and organizing a team, team leader skills, and team members' attributes. Issues related to team training and motivation are folded in to complete the recipe for success.

Cleland's work stands apart from others because of its exceptional scholarship. Richly enhanced by citations and bibliographic references, *Field Guide to Project Management* is an abundant source of information, relevant for immediate and future use by anyone in the acquisition community.

## Analyzing Outsourcing

By Daniel Minoli

McGraw-Hill Inc. Press, 1995

**Reviewed by J. Michael Brower, formerly a program analyst with the Office of the Assistant Secretary of the Army for Financial Management and Comptroller at the Pentagon.**

Outsourcing has been declared a key component of the modernization funding strategy outlined in the Quadrennial Defense Review (QDR) released by the Department of Defense (DOD) on May 19, 1997. In addition, the National Performance Review initiatives that are "reinventing" government hold outsourcing and its first cousin, privatization, to be leading methodologies for cost savings and cost avoidance in the late 1990s. Therefore, books like Dan Minoli's *Analyzing Outsourcing* will be closely scrutinized as the government continues to place outsourcing in general, and outsourcing information technology (IT) specifically, at the top of its money-saving strategies.

Minoli explains that outsourcing is the movement of work that has been or might be performed in-house, to an outside provider. Privatization, frequently mentioned in the same breath, can be thought of as outsourcing writ large: the government farms out the function and often the financial resources to do it, getting out of a business more logically performed by the private sector.

American companies outsource more than \$100 billion a year with average cost savings of 10 to 15 percent. The federal government

spent around \$114 billion on outsourcing during 1995 but lacked the mechanisms (e.g., activity-based-costing (ABC) models) for calculating savings. Minoli's book fills in some of the gaps in available literature that tend to avoid establishing hard numbers and methodologies for determining if an outsourcing project is really economical in both the long and short run. For example, Chapter 3, "Financial Techniques," addresses the near-universal complaint of those charged with overseeing outsourcing projects that solid analytical models are unavailable or inadequate. Refreshingly in Minoli's book, concepts in lease options, return on investment, cash flows and capital budgeting are all explained in connection with outsourcing strategies through mathematical formulas that mirror generally accepted accounting practices.

Minoli further suggests cures for a common ailment affecting many program managers charged with outsourcing a function while maintaining an administrative role. Frequently, a contractor bids for outsourced work claiming substantial savings, but once the government employees are released or transferred to other tasks or organizations, costs increase substantially. The government then has to accept the higher costs because in-house employees and resources have been eliminated in the name of "savings" and "efficiencies." Minoli suggests taking precautions when managing an outsourcing initiative:

- Define realistic expectations in terms of contractor cost reductions, access to skilled people, and customer satisfaction.
- Don't outsource your problems—you can't expect good results from contracting out disorganization.
- Maintain communications with the outsourcing stakeholders.
- Use reliable models to measure expenses, long-term payoffs, and risks.
- Always examine the fine print in the outsourcer's contract.
- Measure results against expectations.
- Don't expect miracles. Outsourcing is a management tool, not a substitute or an "out" for good project management.

The QDR's suggestion that DOD largely remove itself from the IT line of work, or outsource it to contractors, makes Minoli's insights especially relevant. He reminds us that outsourcing has "run many companies aground." Typically, the outsourcer bids low, gains exclusive rights to control an entire IT department, and then charges the outsourcee with cost overruns.

Minoli does point out instances of economical outsourcing in state and local governments, especially when results were measured using an ABC approach. However, Henry Hazlitt the noted conservative commentator, reminded us in his classic *Economics in One Lesson* (1946) that "in studying the effects of any given economic proposal we must trace not merely the immediate results but the results in the long run, not merely the primary consequences but the secondary consequences, and not merely the effects on some special group but the effects on everyone." Minoli provides the important message that not only must we be concerned with the long-term effects of outsourcing (particularly on personnel), but also with effects on our acquisition and procurement strategies.

One of the few drawbacks of Minoli's analysis is that he overlooks the reduced cost of labor that can be realized with outsourcing, one of its primary economic attractions. Although substantial savings can be realized from specialization of technique, improved processes, etc., a reduction in payroll is the quickest, most visible manifestation of savings.

*Analyzing Outsourcing* is an outstanding guide that will benefit those interested in managing outsourcing as well as those affected by this new management paradigm.

(Special Note: Brower gratefully acknowledges the assistance of Patricia Tugwell, research librarian at the Pentagon Army Library, in researching this review.)

## Army Recognizes Outstanding R&D Organizations

Since 1975, the Assistant Secretary of the Army for Research, Development and Acquisition (ASARDA) has presented Army Research and Development Organization (RDO) Awards to Army organizations in recognition of outstanding programs executed during the previous fiscal year. The best research and development (R&D) programs enhance the capability and readiness of Army operational forces and enhance the national defense and welfare of the United States.

RDO Award recipients are selected by an Evaluation Committee chaired by the Director for Research and Laboratory Management and composed of highly qualified members of the Army science and technology community. The committee evaluates a written nomination in booklet format and a verbal presentation by each organization's commander or director. The primary areas of consideration are accomplishments and impact; organizational vision, strategy, and plan; resource utilization; and continuous improvement.

Based on the evaluations of accomplishments during 1996 and 1997, the Evaluation Committee selected co-winners for the RDO of the Year Award, one winner for the RDO Excellence Award, and one winner of an RDO Special Award. The winners and their accomplishments are as follows:

### Army R&D Organization Of The Year Award

The U.S. Army Waterways Experiment Station (WES) and the U.S. Army Communications-Electronics Command Research, Development and Engineering Center (CERDEC) were selected as co-winners of the RDO of the Year Award based on their outstanding 1996 programs, accomplishments and management initiatives.

In 1996, WES continued its outstanding track record supporting numerous Army programs and achieving significant



MG Peter C. Franklin (left), Office of the ASA(RDA), presents a 1997 RDO of the Year Award to Dr. Robert Whalin and COL Robin Cababa of the U.S. Army Corps of Engineers Waterways Experiment Station.



Acting ASA(RDA) Dr. Kenneth J. Oscar (left) presents a 1997 RDO of the Year Award to Dr. Louis Marquet, Director of CERDEC.

technological breakthroughs in multiple areas. WES was recognized specifically for developing and applying expertise and specially developed technologies to critical warfighter needs and real time problems. Projects and programs conducted by WES during 1996 enabled the Army to implement a number of quick fixes for ground troops in Bosnia. WES also responded quickly to worldwide concerns about terrorist activities such as the bombing of Khobar Towers. This is the second consecutive year (and the third time since 1990) that WES has received an RDO of the Year Award.

Equally impressive was CERDEC's performance. Throughout 1996, CERDEC's focus was on providing the underpinnings for building a "bridge" to enable transition to the fully integrated digital battlefield envisioned for the 21st century. CERDEC was recognized specifically for a number of significant technical efforts in support of Task Force XXI that led to a very successful demonstration of advanced communications capabilities in the 1997 Advanced Warfighting Experiment. CERDEC also won four RDO Excellence Awards in the 1990s.

### Army R&D Organization Award For Excellence

The U.S. Army Tank-automotive and Armaments Command Armament Research, Development and Engineering Center (TACOM-ARDEC) was selected to receive this award for demonstrating exemplary transition activities as well as excellent, innovative management initiatives. Specific recognition was given for the successful type classification of 29 armament items, completion of 10 materiel releases for critical items, and development of a unique teaming arrangement with United Defense Limited Partnership for the development of the Crusader's armament system. The ARDEC, which joined TACOM in the fall of 1995, has won one RDO of the Year Award and four RDO Excellence Awards in the 1990s.

## AWARDS



Acting ASA(RDA) Dr. Kenneth J. Oscar (left) presents the 1997 RDO Excellence Award to Carmine Spinelli, Technical Director of TACOM-ARDEC.

### Army R&D Organization Special Award

The Evaluation Committee exercised its option to give a Special Award in recognition of the organization that demonstrated the most improvement during 1996. The U.S. Army Medical Research Institute for Chemical Defense (MRICD) was selected to receive this award for achieving noteworthy advances in medical countermeasures, procedures, and doctrine for the prevention and management of chemical casualties. MRICD also won an RDO Excellence Award in the 1990s.



Acting ASA(RDA) Dr. Kenneth J. Oscar (left) presents the 1997 RDO Special Award to COL James Little, Commander, MRICD.

### The Next RDO Awards

In 1998 (for 1997 achievements), the ASARDA will present RDO Awards for Organization of the Year and Excellence in two categories: Large R&D Organization and Small R&D Organization. The intent is to recognize outstanding Army R&D organizations that contribute to enhancing the Army's capabilities and readiness. Having the two categories will allow R&D organizations with a wider range of personnel and funding resources to be recognized.

### ATC Employees Receive TECOM Professional Awards

Seven Aberdeen Test Center (ATC) employees received the U.S. Army Test and Evaluation Command (TECOM) Professional Award for exemplary performance earlier this year at a special ceremony in ATC's command conference room. The TECOM Professional Award is an honorary award that recognizes outstanding professional performance of assigned duties. It includes an engraved pewter keychain and a citation certificate that can only be presented by the TECOM Commanding General.

MG Edward L. Andrews, Commander of Aberdeen Proving Ground and TECOM, presented awards to William C. Frazer, who was honored for outstanding efforts in testing and analyzing the automotive performance of the T-72 Soviet Main Battle Tank and for other efforts related to foreign equipment; SSG Carlindean Hardy, who was recognized for her outstanding administrative support to ATC and the Headquarters and Military Support Company; Paul D. Hutchins, who was recognized for extraordinary skill, professionalism, and dedication that contributed to the accomplishment of the mission requirements of the Experimental Fabrication Team; Barbara L. Jones, who was cited for outstanding support to the ATC headquarters team; Rebecca C. Joy, who was recognized for scientific expertise that resulted in the successful implementation of the National Target/Threat Signatures Data System at ATC; William H. Taylor Jr., who was recognized for his involvement in the ATC Reengineering Advisory Committee; and Terrence J. Treanor, who was cited for his management of the Halon Alternatives Engine Compartment Test.

ATC Commander Richard O. Bailer said, "ATC has great professionals who do great things for the Army. It's a credit to this organization that we have the type of people that TECOM recognizes."

*The preceding article was written by Lena Goodman, Public Affairs Specialist at the U.S. Army Aberdeen Test Center, Aberdeen Proving Ground, MD.*





*The Hammer Award Ceremony, held earlier this year at the Pentagon, was hosted by Acting Secretary of the Army Robert M. Walker (shown front row, third from the left).*

## Acting Secretary Of The Army Walker Hosts Hammer Award Ceremony

Robert M. "Mike" Walker, Acting Secretary of the Army, hosted Vice President Al Gore's Hammer Award ceremony in the Pentagon earlier this year. The Hammer Award is presented to teams of federal employees who have made significant contributions in support of reinventing government principles. The award is the vice president's answer to yesterday's government and its \$400 hammer. More than 1,000 Hammer Awards have been presented to teams comprised of federal employees, state and local employees, and citizens who are working to build a better government. Fittingly, the award consists of a \$6 hammer, a ribbon, and a note from Vice President Gore, all in an aluminum frame. In addition to the plaque, each recipient receives a certificate signed by the vice president and a "hammer pin."

This year's Hammer Award recipient is the Army Science and Technology Personnel Demonstration Team. The team includes representatives from the following: U.S. Army Materiel Command's (AMC's) Army Research Laboratory; the Aviation and Missile Command's Missile Research, Development and Engineering Center and Aviation Research, Development and Engineering Center; the Medical Research and Materiel Command; and the Corps of Engineers Waterways Experiment Station. The team leader for this effort was Dr. Robert S. Rohde, Associate Director for Laboratory Management, Office of the Assistant Secretary of the Army for Research, Development and Acquisition. The deputy team leader was Janice Lynch of AMC Headquarters. The 37 recipients also included

employees from the Office of the Assistant Secretary of the Army for Manpower and Reserve Affairs; the Army General Council; AMC Headquarters; the Office of the Secretary of Defense for Civilian Personnel Policy; and the Office of Personnel Management (OPM).

The Army team received the Hammer Award for the five demonstrations they initiated to change the personnel systems within these laboratories. This highly complex process evolved over a 3-year period. It involved the participation of the local unions and the workforce, and resulted in publication in the *Federal Register* of the new rules under Title V governing the respective organizations. The approval process included the Army, the Office of the Secretary of Defense, and OPM.

The ceremony included remarks by Bob Stone, Director of the National Performance Review, Walker, and Rohde. In his remarks, Stone spoke about the history of the Hammer Award and the fact that savings to the taxpayer total billions of dollars. Walker stressed how this effort will improve the quality of the Army laboratories and ultimately the materiel provided to the warfighter. Rohde discussed the long, arduous process for changing the personnel systems. He accepted the Hammer plaque on behalf of the team and the Department of the Army's Office of the Director for Research and Laboratory Management. Linda Walker, special assistant to Vice President Gore, was also in attendance.

## From The Acquisition Reform Office...

### Sale And Exchange Authority

The Department of Defense (DOD) has given the Army authority to sell as well as exchange old or obsolete non-excess personal property until Aug. 1, 1999. Until now, DOD only authorized exchange authority. In acquiring personal property, an agency may exchange or sell similar items and apply the allowance or proceeds as payments, in whole or in part, to the new property. *If sale or exchange authority is not used*, old or obsolete equipment is generally declared excess and screened for possible use by other government agencies before it is disposed of through donation or sale; in this case the Army gets no value for it. *Through sale and exchange authority*, the Army receives value by applying the proceeds or exchange credits to the acquisition of similar items. Recent examples of using the exchange authority include exchanging old helicopter engines for credit during remanufacture and systems upgrade, and exchanging old and obsolete turret trainers for new ones. See Federal Property Management Regulation 101-46 and DOD 4140.1R for conditions attached to the use of this authority. For additional information on this policy, contact Curtis Stevenson at (703) 681-1041, or e-mail [stevensonc@sarda.army.mil](mailto:stevensonc@sarda.army.mil).

### AR Advocacy Network Established

The Army's Acquisition Reform (AR) Advocacy Network is up and running. The AR Advocacy Program was established by the Acting Assistant Secretary of the Army (Research, Development and Acquisition) in December 1997. The program's objective is to foster, promote, advocate and facilitate an integrated team effort to accelerate institutionalization of AR initiatives and improvements; adopt and improve new ways of doing business; and create awareness of and access to new technologies. The AR Advocacy Network will help the Army work as an integrated team as it strives to build the Army of the 21st century by providing soldiers with what they need, when they need it, and at an affordable cost. To this end, each major commander and program executive officer is required to designate an individual as its AR advocate/champion and empower the individual to:

- Develop vision, guidance, information, and focus to implement and institutionalize regulatory and business practice reforms.
- Instill regulatory reform, streamlining, and process changes within the organization.
- Provide insight to acquisition reform strategic planning and improvement processes.
- Disseminate best practices, lessons learned, and successes.
- Identify and facilitate implementation of new initiatives.
- Identify and facilitate removal of impediments, barriers, and challenges to acquisition reform implementation.
- Speak for his or her organization/command in responding

to Army requirements.

### Another Banner Year For The Army's Value Engineering Program

The Value Engineering (VE) Program, which provides incentives for both government and contractor workforces to submit ideas for improving products, processes, and production methods, continued to pay dividends in FY97. The Army more than doubled its projected goal, saving more than \$404.8 million. Using VE Change Proposals, which are cost-saving recommendations submitted by a contractor in accordance with the VE provisions of its contract, the Army saved \$23.1 million. Government ideas, termed VE Proposals (VEPs), saved more than \$381.7 million. Below are some of the noteworthy contributions to the Army's success.

- The Theater High Altitude Area Defense Program Office reported savings of \$16.5 million by implementing a VEP that recommended the acquisition of an additional electronics unit in lieu of upgrading the existing radar units.
- Using a VEP, the Soldier Systems Command saved more than \$155 million by changing the Desert Battlefield Uniform from 100 percent cotton to a blend of 50 percent cotton and 50 percent nylon fiber, doubling the service life and making the uniform lighter and more comfortable. The new uniform has been approved by all three Services.
- A VE analysis determined that the shelf life of the M9 Chemical Agent Detector Paper could be extended from three to at least six years, saving the government \$3.5 million.
- The government saved \$1,526,000 by implementing a VEP to use common M185/M284 cannon components for the M109A6 [PALADIN] upgrade from the M109A5, eliminating the requirement to purchase new components.
- The Army saved \$2,657,000 by eliminating Army-administered C-12 training. A VE study determined that a contractor could lease a C-12 military aircraft for the training of rotary wing aviators to fly fixed wing aircraft. The contractor had previously only trained with the civilian model A-90 multi-engine aircraft. Allowing the contractor to conduct both C-12 and A-90 training eliminated the need for the follow-on Army course using the C-12.

### The AN/ARC-210 Aircraft Radio: An MTS Success

The Modernization Through Spares (MTS) initiative is an integral part of the AN/ARC-210 improvement program. A government and contractor Integrated Product Team shared risk and responsibility in negotiating a contract for a reliability improvement warranty that included a 120 percent improvement in the mean time between failure (MTBF) rate. The contract required the government to reduce the level of configuration control and designated the contractor to perform depot-level repairs. The contractor included a 5-year fixed-price warranty on all units and will get incentives for exceeding MTBF guarantees. This effort resulted in a 25 percent reduction in unit costs, and the elimination of non-value added military specifications.

For additional information on acquisition reform articles, contact LTC Linda Hooks at (703) 681-9479, or e-mail: [booksl@sarda.army.mil](mailto:booksl@sarda.army.mil).

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